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An Atlas of the Distribution and Abundance of Dominant Benthic Invertebrates in the New York Bight Apex with Reviews of Their Life Histories

Janice V. Caracciolo and Frank W. Steimle, Jr.

March 1983

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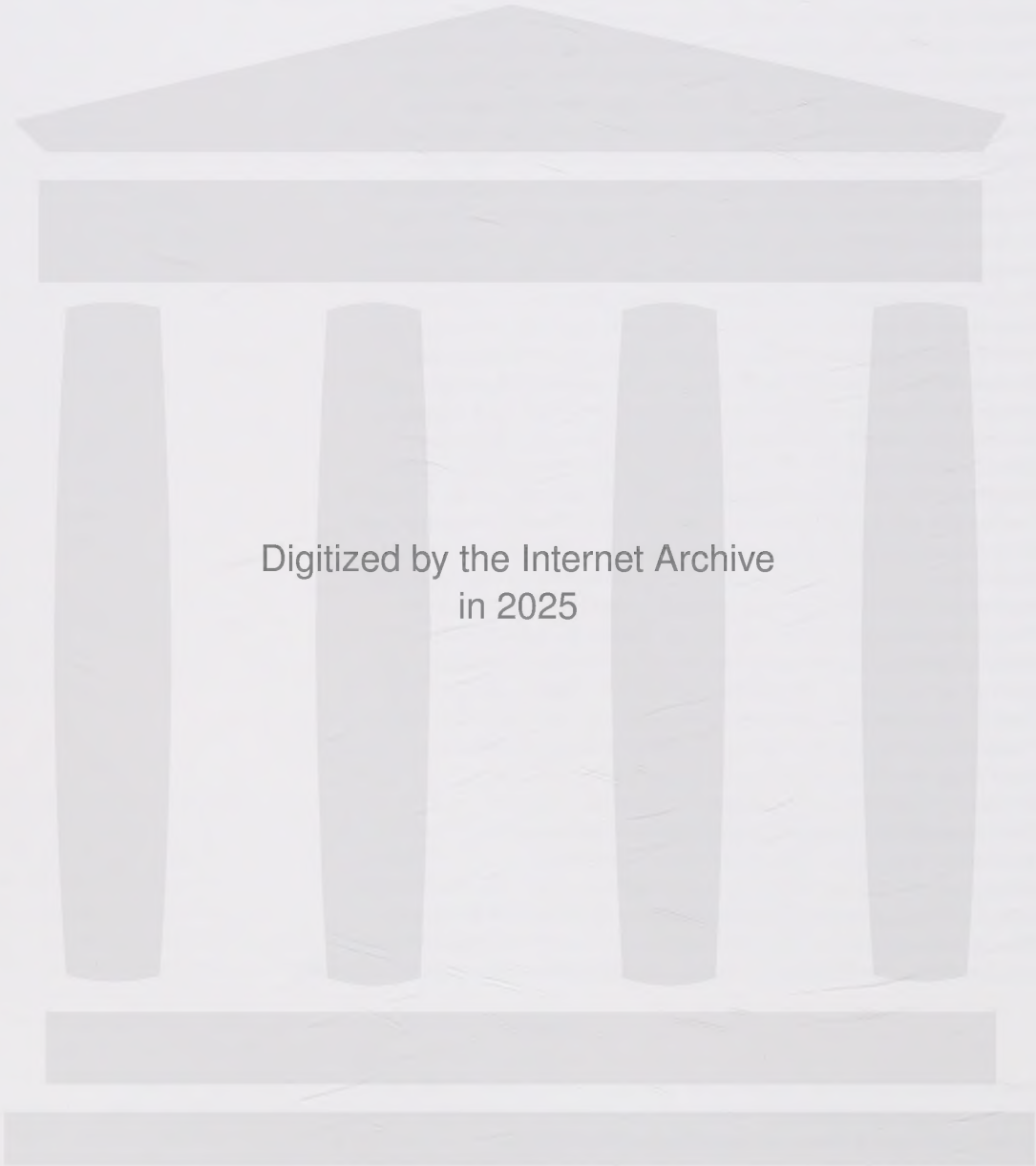

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An Atlas of the Distribution and Abundance of Dominant Benthic Invertebrates in the New York Bight Apex with Reviews of Their Life Histories

JANICE V. CARACCIOLO and FRANK W. STEIMLE, Jr.[1]

ABSTRACT

Distribution, abundance, and life history summaries are given for 58 important species of benthic invertebrates collected in the New York Bight apex during five sampling cruises in 1973 and 1974. These species showed affinities to major community types that have been previously identified in the Middle Atlantic Bight and some showed varying degrees of tolerance of areas in the apex where the dumping of New York Harbor dredge spoils and New York metropolitan area sewage sludge occurs. *Capitella capitata*, a species often associated with pollution stress, dominated the sewage sludge dump site.

INTRODUCTION

The New York Bight apex (Fig. 1), the area of continental shelf waters bounded on the north by Long Island and by New Jersey on the west, is one of the most intensely used areas of coastal marine waters in the world. It is impinged upon by a major population center, the New York-New Jersey metropolitan area, which uses the apex for recreation, for harvesting fish and (formerly) shellfish, and as a repository for waste products. The apex is also a thoroughfare for shipping to and from one of the busiest ports in the world, New York Harbor. These diverse uses or interests often conflict, and regulation, for the greatest public good, is a complex and difficult problem. Essential to the regulation of these conflicting interests are good assessments of the impacts each of the uses has upon the others.

The dumping of sewage sludge, dredging spoils, and industrial waste products into the apex and the flow of contaminants from the Hudson and Raritan Estuaries have affected the environment of the apex, degrading it for some purposes, e.g., recreation and shellfish harvesting. Surveys of the distribution and abundance of selected or indicator organisms or communities have often been used as an aid in determining the degree to which an environment has been degraded. Benthic invertebrates are particularly useful for this purpose because of their relative immobility, wide range of life histories, sensitivities to environmental change, and important role in marine food webs.

Man's impact on the New York Bight ecosystem has been noted for almost 100 yr, but surveys of the degree of impact were initiated only within the last two decades. Most studies concerned with benthic populations within the Bight and contiguous waters were also conducted from the mid-1950's to the present, after four decades of ocean disposal of sludges and spoils in the apex and over a century of industrial discharges into estuaries had already had an impact on the marine benthos inhabiting these waters. During 1957–60, Dean and Haskin (1964) and during 1973, McGrath (1974) studied the benthos of Raritan Bay, which borders the apex; in 1966, Steimle and Stone (1973) studied the inshore benthic macrofauna off southwest Long Island, primarily north of the lat. 40°30′N line within the Bight apex. The Middle Atlantic Bight study of Wigley and Theroux (1981) from August 1957 through August 1965 dealt with the New York Bight apex fauna only in major taxonomic groups. The first comprehensive studies of the benthic macrofauna of the New York Bight apex itself were made by personnel of the Sandy Hook Laboratory, National Marine Fisheries Service (NMFS). These studies, begun in 1968, have resulted in several published papers and reports (Pearce 1971, 1972, 1974a, b, 1975; National Marine Fisheries Service 1972[2]; National Oceanic and Atmospheric Administration 1976; Pearce, Caracciolo, Halsey, and Rogers 1976). Numerous benthic data reports have also been published by the NOAA-MESA Program (Pearce, Caracciolo, Frame, Rogers, Halsey, and Thomas 1976; Pearce, Thomas, Caracciolo, Halsey, and Rogers 1976a, b; Pearce, Caracciolo, Halsey, and Rogers 1977a, b; Pearce, Rogers, Caracciolo, and Halsey 1977; Pearce et al. 1978; Caracciolo et al. 1978). This atlas uses part of this extensive data set, collected during the MESA studies of 1973 and 1974, to present distribution and abundance patterns for the more important or dominant benthic macroinvertebrates in the New York Bight apex. The atlas describes and reviews the environment in which the species occur and presents a summary of aspects of their life histories. Through this approach, we hope to qualify the observed distributions and to gain insight into distinguishing natural and man- or pollution-induced population abundances and distributions. This report also forms a part of the baseline which is being established by the long-term ocean monitoring program, Ocean Pulse (Pearce 1977),[3] of the Northeast Fisheries Center, NMFS.

METHODS

Information on distribution patterns of species, sediment types, organic material, and heavy metals used in this paper was derived from approximately 500 benthic grab samples collected from a grid of 66 stations established in the New York Bight apex. These stations are bounded by lat. 40°16′ and 40°34′N and long. 73°36′

[1]Northeast Fisheries Center Sandy Hook Laboratory, National Marine Fisheries Service, NOAA, Highlands, NJ 07732.

[2]National Marine Fisheries Service. 1972. The effects of waste disposal in the New York Bight. Final Report, Section 2: Benthic studies. A report submitted to the coastal Engineering Research Center, U.S. Army Corps of Engineers, Little Falls Road, Wash., D.C., 63 p.

[3]Pearce, J. 1977. A report on a new environmental assessment and monitoring program, Ocean Pulse. Int. Counc. Explor. Sea Pap. m1977/E:65, Fish. Improvement Comm., 12 p.

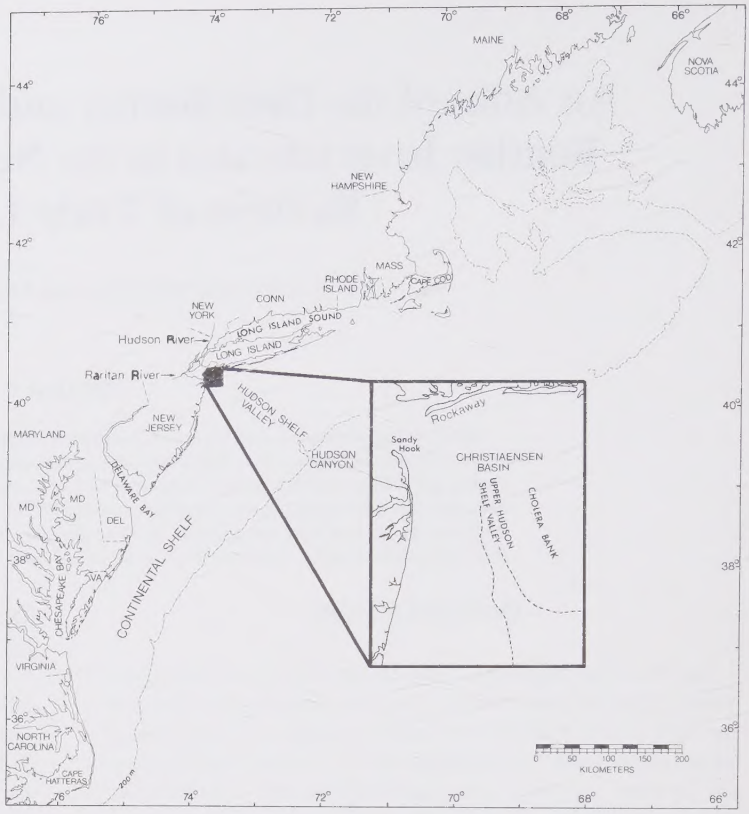

Figure 1.—New York Bight apex (enlarged) and surrounding area.

and 73°59′W, their depths ranging from 9.0 m nearshore (Station 16) to 45.6 m in the Hudson Shelf Valley (Station 56) (Fig. 2). Data were collected from on board the NOAA ships *Albatross IV*, *Oregon II*, and *Delaware II* during August 1973, October 1973, January 1974, March-April 1974, and August-September 1974 (Pearce, Rogers, Caracciolo, and Halsey 1977). Station positions were located and maintained by Raydist precision navigation and loran-A.

Benthic Fauna

At each station, during each cruise, five 0.1 m^2 Smith-McIntyre benthic grab samples were collected. Before the samples were disturbed, one 2.54 cm (inside diameter) core subsample was removed from each grab and preserved in Formalin for future study of meiofauna. Two sediment cores were also removed, and then the remainder of each grab sample was washed through a series of standard geological sieves with a minimum 1.0 mm mesh size. All materials retained on the sieves were fixed in 10% buffered Formalin and later transferred to and preserved in 70% ethanol containing 5% glycerol.

Dissecting microscopes were used as an aid in sorting organisms from preserved macrofauna samples. The organisms found were identified to the species level, whenever possible, using keys and descriptions developed by Hartman (1957, 1968, 1969), Pettibone (1963), Williams (1965), Day (1967), Abbott (1968, 1974), G. Schultz (1969), Gosner (1971), Bousfield (1973), and others. Competent taxonomists were consulted when necessary. After organisms were identified, counted, and tabulated, this information was coded and machine-listed by computer. The community found at each station was analyzed for total number of individuals per grab (N), total number of species (S), equitability ($J' = H'/H'$ max $= H'/\ln S$) (Pielou 1969), and diversity ($H' \cong \frac{-\Sigma n_i}{N} \ln \frac{n_i}{N}$ where n_i = the number in the ith species, Shannon and Weaver 1962).

Upon completion of a total of approximately 500 samples, a computer program was written to extract the "key" or "important" species found in the Bight apex. A species was defined as important if it was abundant, widely distributed, a known forage species for finfish (based on studies discussed later), a fishery resource species, or if it possessed characteristics or behavioral traits which make it useful as an "indicator" species, e.g., *Capitella capitata*. This selection yielded a total of 58 species.

The next step in our analysis was to combine and average distribution and abundance data from summer cruises (August 1973, October 1973, and August-September 1974) and from winter cruises (January 1974 and March-April 1974) for each of the 58 important species. This yielded average numbers of individuals of each species at each station sampled. These numbers were multiplied by 10 to give numbers per square meter, plotted, and contoured on standard station maps. In most cases, summer and winter species distributions were similar, so seasonal data were combined into one overall map for each species, which will be presented in the Life Histories.

Average species diversities and numbers of individuals at each station were plotted in Figures 3 and 4.

In the narrative sections of this atlas, we have reviewed and summarized available information on distribution, habitat, feeding ecology, reproduction, growth, and other unique or important characteristics for each of the above-mentioned "key" organisms, and have attempted to relate this information to the benthic environment in the New York Bight apex.

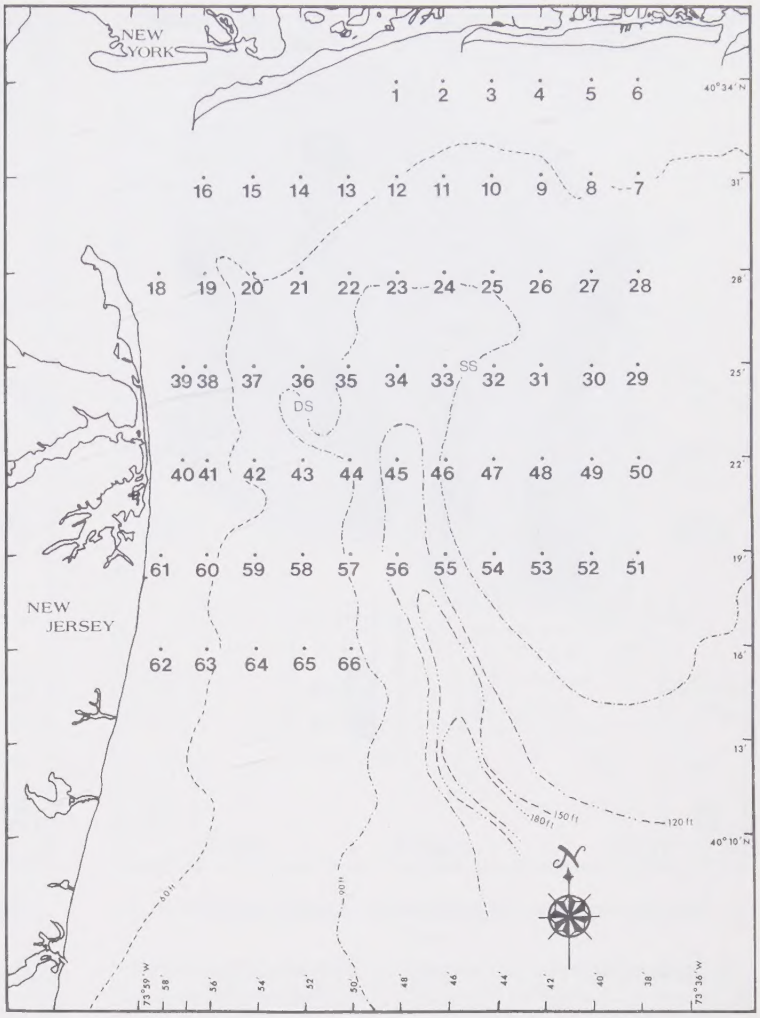

Figure 2.—New York Bight apex study area with station positions, and dredging spoils (DS) and sewage sludge (SS) dump sites indicated.

Sediments

Two 3.4 cm (inside diameter) sediment cores were removed from each grab sample, one for standard geological analyses (percentage oxidizable organics and grain size distribution) and the other for heavy metals analyses. These cores were frozen before being analyzed.

The percentage of oxidizable organic material in the sediments was calculated by the hydrogen peroxide digestion method, and grain size distribution was determined by processing each sediment sample in a Rapid Sediment Analyzer (Cok).[4] Grain size, expressed in the Wentworth scale (Wentworth 1922 after Udden 1898 as seen in Shepard 1963) is given in ϕ (phi) units, where $\phi = -\log_2 d$, and d = particle diameter in millimeters. Sediment heavy metals analyses for chromium, copper, nickel, lead, and zinc were performed using an atomic absorption spectrophotometer; details of these methods are given in Greig et al. (1976).

Sediment grain size, organic content, and heavy metals data were combined and averaged using procedures similar to those used for benthic fauna data. Mean grain size, expressed in ϕ units, was converted into sediment types based on the Wentworth scale. The categories thus established are as follows: -1 to $+1\phi$ = very coarse-coarse sand; $+1$ to $+2\phi$ = medium sand; $+2$ to $+4\phi$ = fine-very fine sand; $+4$ to $+6\phi$ = coarse to medium silt. These are mapped in Figure 5.

Sediment organic content was divided into three categories: $<3\%$ represents low organic areas; 3–5% represents medium organic areas; and $>5\%$ represents high organic areas (Fig. 6).

Average concentrations (ppm) for five heavy metals—chromium, copper, nickel, lead, and zinc—are presented in Figures 7–11.

The data file and benthic samples, upon which much of the information presented in this paper is based, are stored at the Northeast Fisheries Center, Sandy Hook Laboratory.

NEW YORK BIGHT APEX STUDY AREA

Environmental Characteristics

The oceanography of the New York Bight depends on larger scale processes of the entire Middle Atlantic Bight. Water depths in the Bight apex range from intertidal to approximately 62 m in the Hudson Shelf Valley. East coast continental shelf waters, in general, flow to the south at average speeds between 5 and 10 cm/s, however, storms can cause movements of 25–30 cm/s. Waters of the inner New York Bight exhibit estuarine circulation typical of coastal areas where discharge of river water exceeds evaporation. Near-surface waters move generally seaward, while near-bottom waters move generally landward (Beardsley et al. 1976).

[4]Anthony Cok, Department of Earth Sciences, Adelphi University, Garden City, NY 11530, pers. commun. June 1973.

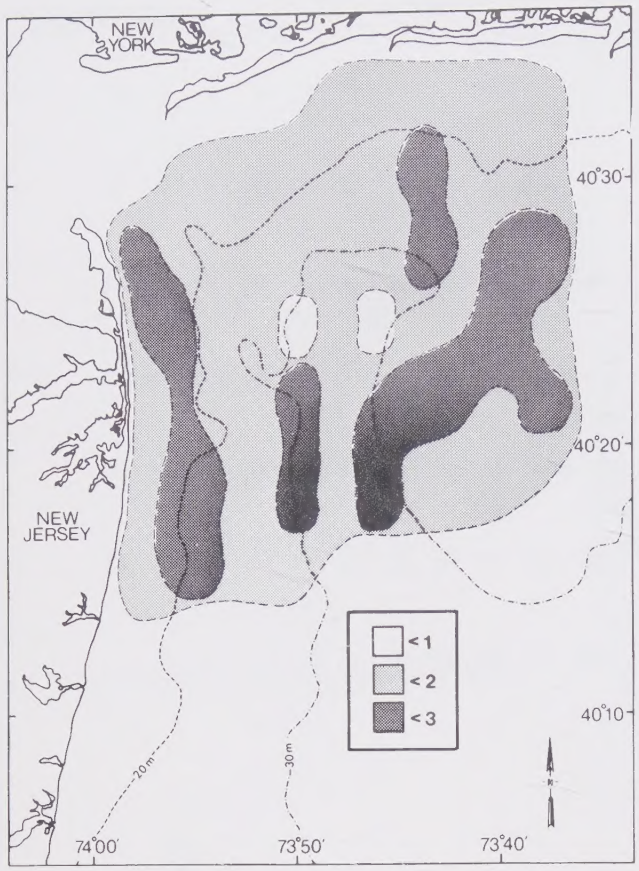

Figure 3.—Average species diversities (H') of benthic invertebrates.

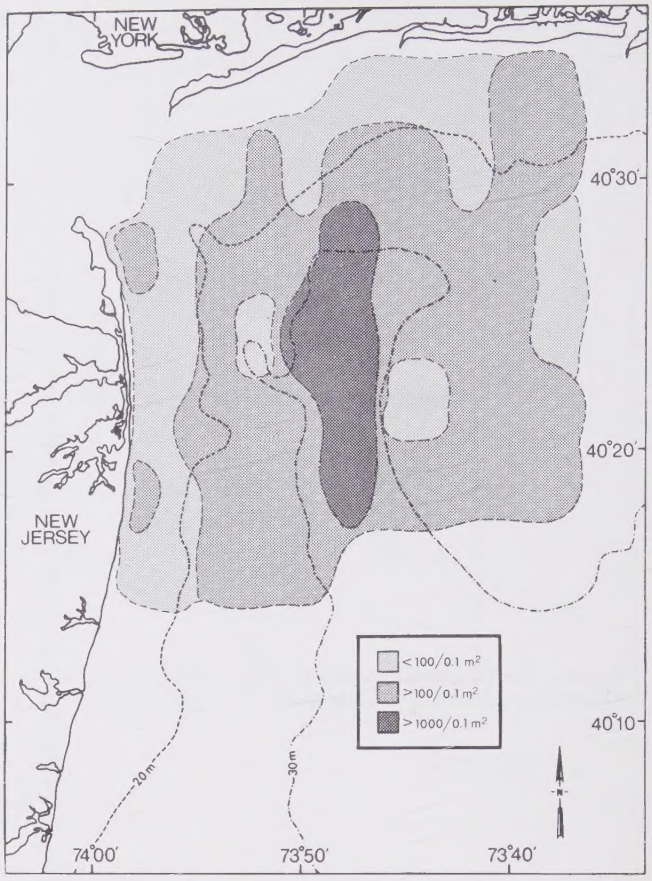

Figure 4.—Average numbers of benthic invertebrates per square meter.

In the Bight apex, surface salinities during January and February increase to the annual maximum of >34‰. Bottom salinities are >34‰ over most of the apex. Salinities begin to slowly decrease in March as river discharges increase. The spring (April, May) river runoff and penetration of slope water tend to increase vertical salinity gradients, however, these gradients vary greatly, even over a few days. Summer (June, July, August) surface salinities range from about 25–27‰ near the apex mouth to about 30–31‰ at the southeast corner. Bottom salinities range from 27–29‰ along the Sandy Hook-Rockaway transect to 30–32‰ at the outer edge of the apex. The seasonal minima occur in June. Vertical mixing during autumn (September, October) reduces vertical salinity gradients and leads to a steady increase in surface salinity, often as large as 0.8‰ between July and October. Surface and subsurface salinities continue to increase through early winter (November, December) until the winter maxima are attained in January.

A large range between summer and winter surface temperatures is characteristic of the Bight. River runoff into the apex is low in winter when strong vertical mixing unstratifies the water column and temperatures drop to their annual minimum, often <2°C in mid-January. Bottom temperatures during November through February tend to be slightly higher than surface temperatures because vertical mixing does not keep pace with rapid surface cooling. Winter minima persist into late February or early March. During April, surface temperatures warm to ≈7°–8°C, with bottom temperatures usually remaining at <4°C except near the coast. A thermocline appears in May and intensifies during June when surface

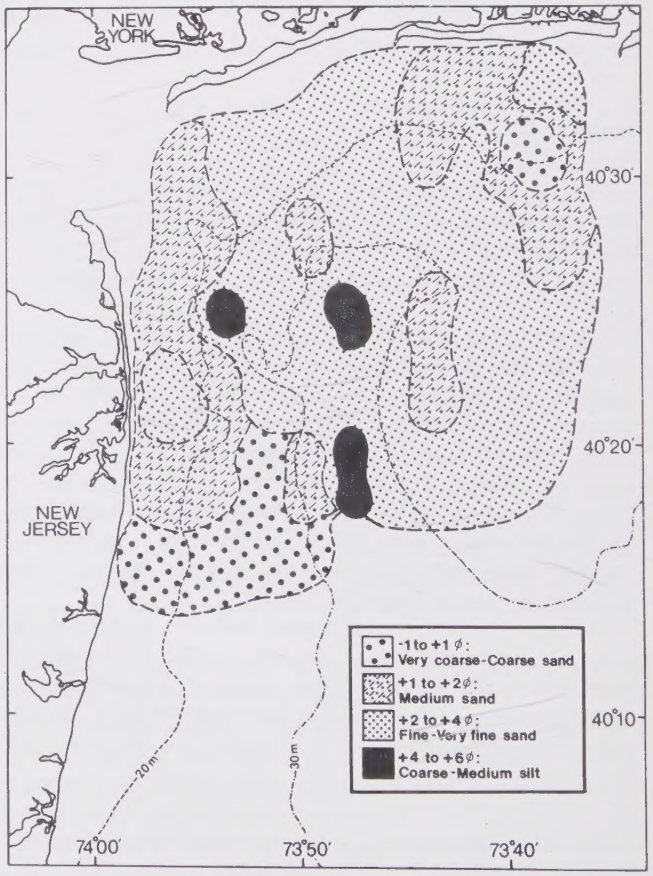

Figure 5.—Mean grain size (ϕ units) of sediments averaged over five quarterly cruises (August 1973–September 1974).

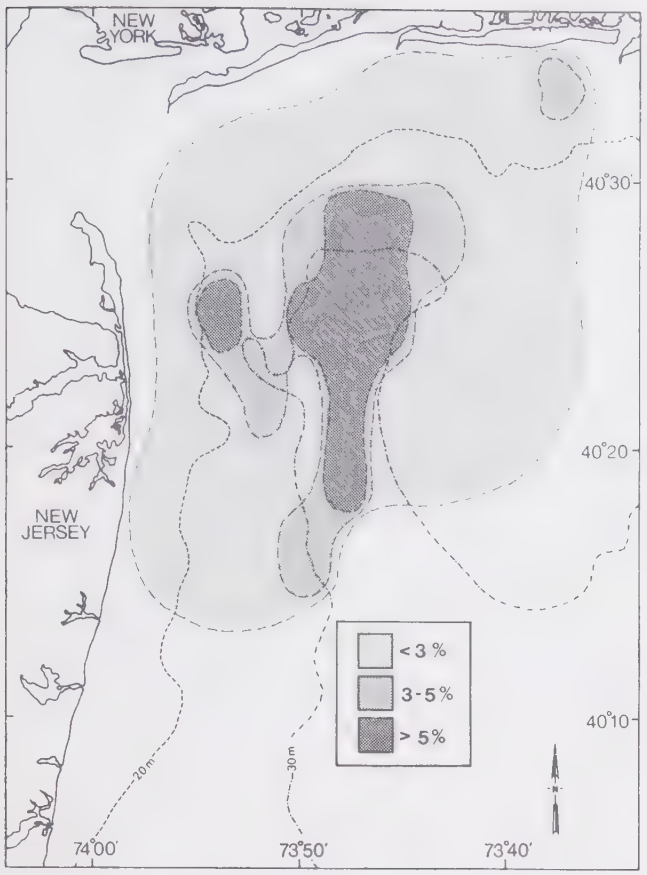

Figure 6.—Average percentage of digestible organic materials in sediments.

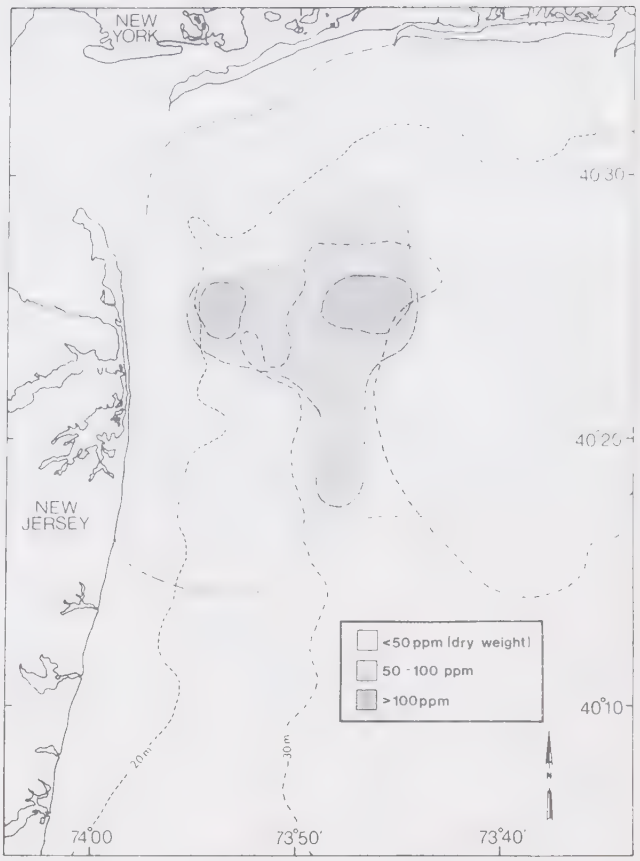

Figure 7.—Average concentrations of chromium in New York Bight apex sediments.

temperatures reach 17°C at the outer edges of the apex. Bottom water temperatures remain relatively unchanged at <6°C in the shelf valley. Surface temperatures reach their annual maximum value of about 26°C in August and bottom temperatures also show a steady rise to ≈10°C in the shelf valley. Surface cooling during early autumn begins to break down the summer thermocline. By the end of October, surface temperatures have dropped to ≈16°–18°C over much of the apex, while heat loss and vertical overturning increase the bottom water temperatures to ≈12°C inside the shelf valley. Vertical mixing down to about 30 m is usually complete by early or mid-November when water temperatures are 12°–14°C. Bottom temperatures attain their annual maximum in this period. Vertical mixing continues through December and surface and bottom temperatures decline and approach their winter minima (Bowman and Wunderlich 1976; Bowman 1977).

The dominant bottom feature of the New York Bight is the Hudson Shelf Valley, apparently cut by the ancestral Hudson River during times of low sea level. The center of the Christiaensen Basin (the landward terminus of the Hudson Shelf Valley Channel) is a natural collecting area for fine grained sediments. The apex outside the Christiaensen Basin is floored primarily by sand ranging from silty fine to coarse with small areas of sandy gravel, artifact gravel, and mud. In deeper water, in the Hudson Shelf Valley, where wave action is less pronounced, silt is the dominant sediment (Williams and Duane 1974; Freeland et al. 1976). Figure 5 shows mean grain size of sediments in the apex.

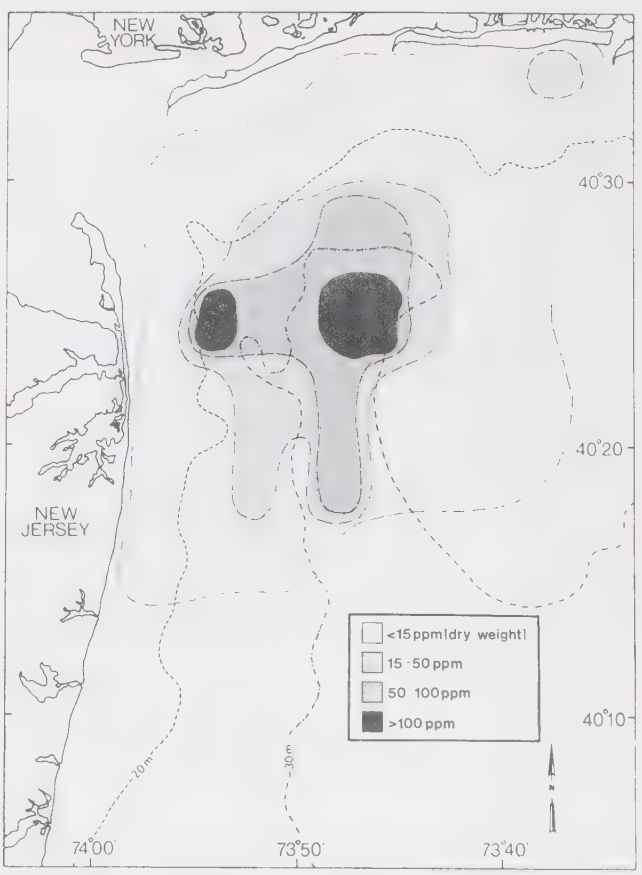

Figure 8.—Average concentrations of copper in New York Bight apex sediments.

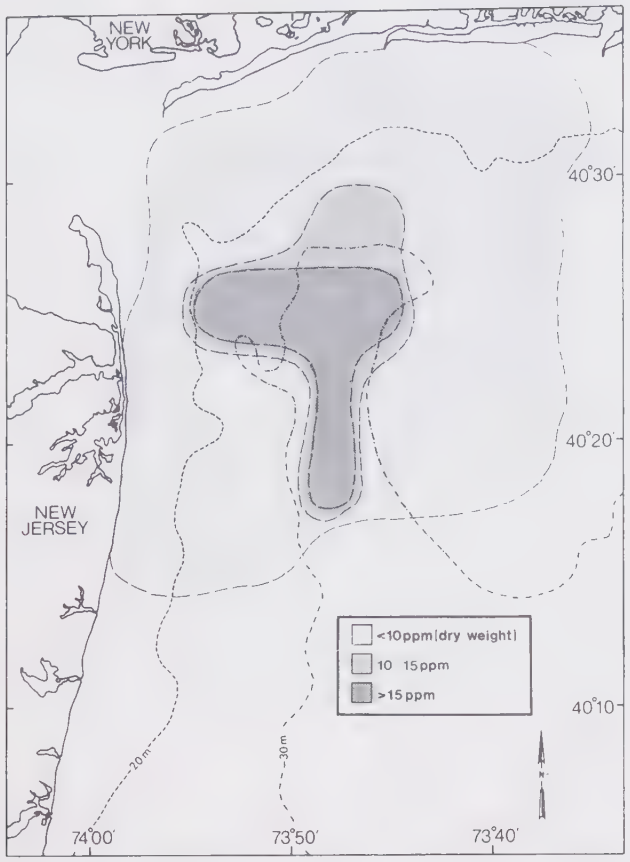

Figure 9.—Average concentrations of nickel in New York Bight apex sediments.

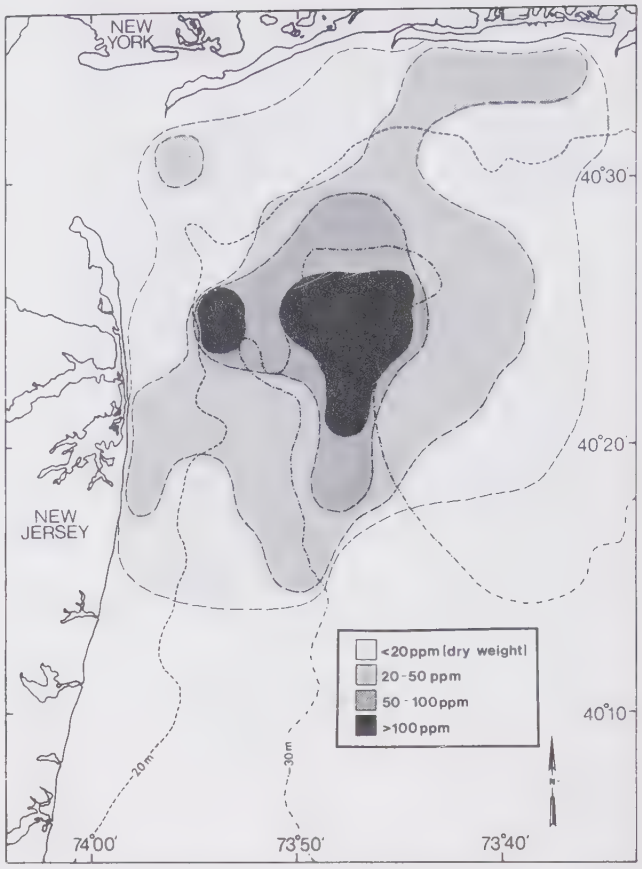

Figure 10.—Average concentrations of lead in New York Bight apex sediments.

Sources of oxygen-consuming organic matter in the New York Bight have been analyzed by Segar and Berberian (1976). They reported that locally produced carbon from phytoplankton accounted for most of the oxygen demand in the apex, especially in summer. Sewage sludge and river-borne organic materials were generally of equal importance. The major contaminants of the New York Bight originate from the highly populated New York metropolitan area and the Hudson River drainage basin. Sources include offshore barged discharges from sewage treatment plants, industrial outfalls, and storm water runoff and overflows.

Hatcher and Keister (1976) analyzed organic matter in the New York Bight sediments using the ratio of total carbohydrates (TCH) to total organic carbon (TOC). TCH:TOC ratios were ≈ 40 in the sewage sludge disposal site and 50 or more in the axis of the Hudson Shelf Channel. High TCH:TOC values (≥ 30) may be attributed to sewage-derived organic material in sediment deposits.

Figure 6 gives a detailed representation of the percentage of total digestible organic material in apex sediments based on our data from five seasonal cruises.

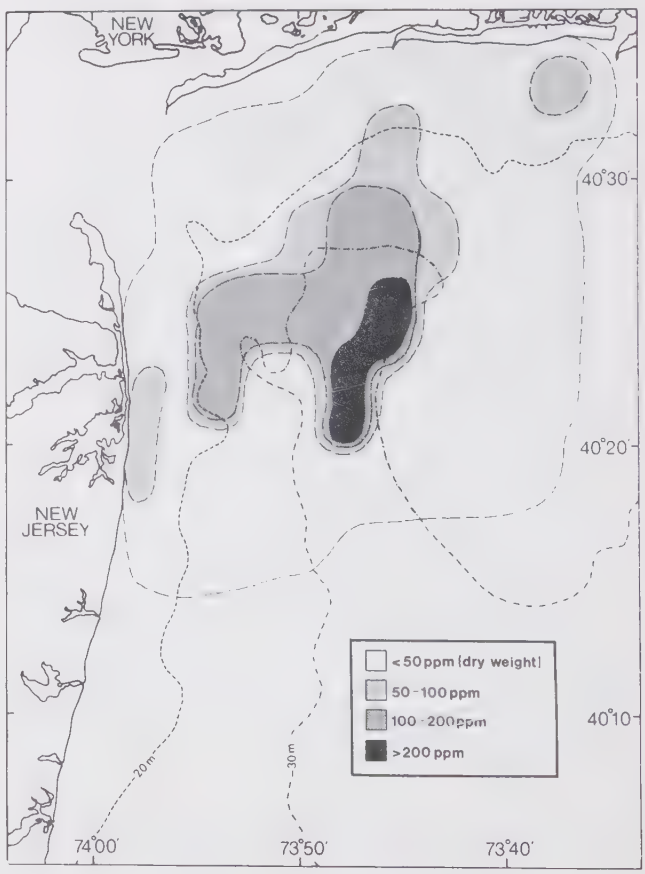

Figure 11.—Average concentrations of zinc in New York Bight apex sediments.

Life Histories and Distributions of Dominant Benthic Invertebrates

Phylum Coelenterata

Class Anthozoa

Edwardsia spp.: *elegans* Verrill, 1869 and *sipunculoides* Stimpson, 1854

DESCRIPTION: Small, slender, solitary anemones between 75 and 150 mm in length. They burrow in the sediment with their tapering "foot" and are often encrusted with sand and other foreign material. Sixteen to 36 mobile tentacles surround the mouth (Miner 1950).

DISTRIBUTION: These two species of *Edwardsia* occur from the Bay of Fundy to at least Chesapeake Bay (Boesch et al. 1977).

HABITAT: Gosner (1971) reported that *Edwardsia elegans* occurs between the littoral and 117 m, while *Edwardsia sipunculoides* is found in deeper water of 87–117 m. In this study, these species were found in depths between 23 and 46 m in abundances of 10–60/m^2. They were most abundant in high organic fine sands or silts (Fig. 12; Table 1).

FEEDING ECOLOGY: Anemones, in general, feed on live or dead animal material ranging from plankton and detritus, collected by ciliary currents, to larger organisms, captured by mucous secretions or nematocysts (Barnes 1963; Gosner 1971). No specific information on *Edwardsia* spp. was available.

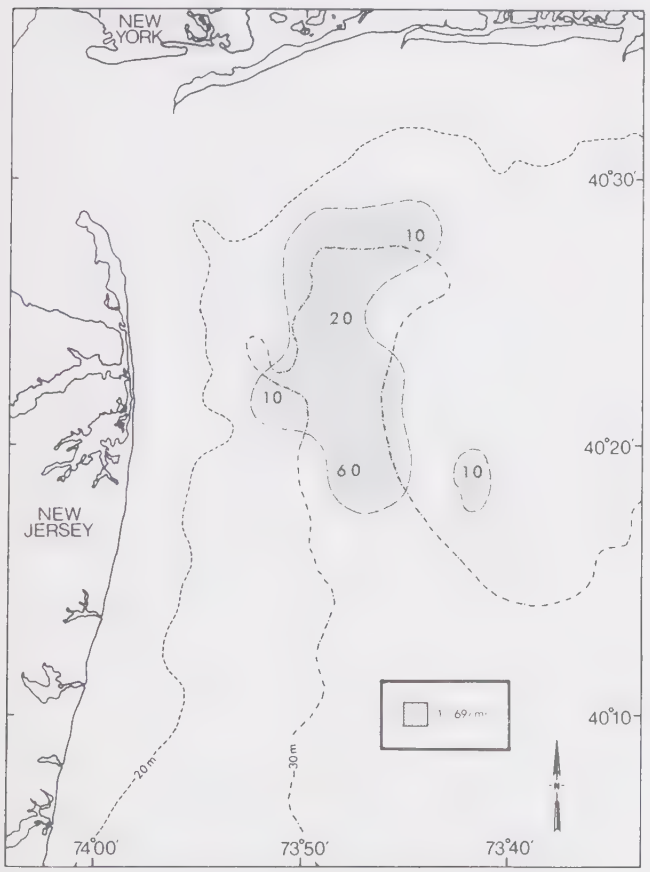

Figure 12.—Distribution and abundance of *Edwardsia* spp. (*E. elegans* and *E. sipunculoides*) in the New York Bight apex.

REPRODUCTION AND GROWTH: No information specific to *E. elegans* or *E. sipunculoides* was available in this category. However, anemones can reproduce both asexually and sexually. Asexual reproduction is chiefly by longitudinal fission (budding). Sexual reproduction can involve individuals which are males, females, or protandric hermaphrodites. A free-living larval form called the planula is produced in sexual reproduction. This larva eventually attaches to a substrate and metamorphoses into the adult benthic form (Barnes 1963; Gosner 1971).

The larvae of some species of *Edwardsia* are parasitic on the surface or in the gastrovascular system of medusae and ctenophores (*Mnemiopsis* sp.), adhering by means of the mouth margin and taking food particles from their hosts by means of the siphonoglyph current (Hyman 1940; Gosner 1971).

Ceriantheopsis americanus [*Cerianthus americanus*] (Verrill, 1866)

DESCRIPTION: A smooth-bodied, brownish, elongate (up to 200 mm), burrowing anemone. It inhabits a distinctive heavy mucous tube, constructed in part with its own nematocysts. The inner surfaces of the tubes are purple or lavender. One hundred or more tentacles, in each of two circlets, surround the mouth (Miner 1950; Gosner 1971).

DISTRIBUTION: Gosner (1971) considered *Ceriantheopsis americanus* to be a Virginian species, occurring from Cape Cod to Cape Hatteras. However, Pratt (1935) and Miner (1950) gave its range as Cape Cod to Florida.

HABITAT: Gosner (1971) reported occurrence of this species from the littoral zone to 21 m. Sanders (1956) reported it to be part of the typical soft bottom community in Long Island Sound; the species was also common in the sewage sludge disposal area of the New York Bight apex (National Marine Fisheries Service footnote 2). In the present study, *C. americanus* was collected in depths up to about 46 m in all sediment types. However, it was most abundant, occurring in numbers up to 340/m^2, in high organic fine sands to silt (Fig. 13; Table 1). The Cerianthidae are often found buried in the sediment with only the tentacles and oral disc protruding; their tubes may confer some protection from stressed environments.

FEEDING ECOLOGY: *C. americanus*, like most smaller anemones, is thought to be a suspension feeder, with its mucous secretions and nematocysts aiding in the capture of small planktonic organisms. An extracellular and extracorporeal contact digestion has also been demonstrated in species of *Ceriantheopsis*. This digestion occurs when prey come into contact with enzymes produced in the ectodermal layer of the labial tentacles (Barnes 1963; Tiffon 1975).

Since *C. americanus* is able to withdraw rapidly into its mucous tube, it avoids being preyed upon by many finfish. However, it has been shown by Wobber (1970) that California species of genus *Cerianthus*, closely related to genus *Ceriantheopsis*, are often the prey of a nudibranch, *Dendronotus iris*. *Dendronotus iris* feeds on *Cerianthus* spp. tentacles, but because it consumes an average of only 2–10 tentacles per anemone, it does minor damage to the anemone.

Table 1.—Total number of individuals per square meter averaged over five quarterly cruises (August 1973–September 1974).

Taxonomic group	Depth (m)		Sediment organic level			Sediment type			
	0–24	25–49	High >5%	Medium 3–5%	Low <3%	Very coarse-coarse sand	Medium sand	Fine-very fine sand	Coarse-medium silt
Phylum Coelenterata	470	2,170	1,910	340	390	60	120	1,710	750
Class Anthozoa	470	2,170	1,910	340	390	60	120	1,710	750
Edwardsia spp. (*E. elegans* and *E. sipunculoides*)	10	190	130	30	40	0	10	110	80
Ceriantheopsis americanus	460	1,980	1,780	310	350	60	110	1,600	670
Phylum Phoronida	360	1,080	930	210	300	10	170	970	290
Phoronis architecta	360	1,080	930	210	300	10	170	970	290
Phylum Mollusca	12,390	42,154	44,810	1,247	8,487	1,150	2,500	37,954	12,940
Class Gastropoda	50	60	20	20	70	0	30	80	0
Nassarius trivittatus	50	60	20	20	70	0	30	80	0
Class Bivalvia	12,340	42,094	44,790	1,227	8,417	1,150	2,470	37,874	12,940
Nucula proxima	7,500	39,840	43,970	620	2,750	560	550	33,600	12,630
Astarte castanea	510	110	0	0	620	390	70	160	0
Arctica islandica	10	144	80	47	27	0	0	124	30
Cerastoderma pinnulatum	30	170	110	50	40	30	20	120	30
Pitar morrhuanus	190	690	400	110	370	20	50	640	170
Spisula solidissima	630	20	0	20	630	10	260	380	0
Tellina agilis	3,450	1,080	220	380	3,930	140	1,490	2,820	80
Ensis directus	20	40	10	0	50	0	30	30	0
Phylum Annelida	47,943	65,380	30,234	14,237	68,852	21,770	23,264	58,292	9,997
Class Polychaeta	43,782	64,016	30,207	13,147	64,444	19,980	20,537	57,301	9,980
Order Archiannelida									
Polygordius triestinus	4,161	1,364	27	1,090	4,408	1,790	2,727	991	17
Order Phyllodocida									
Phyllodoce arenae	208	215	31	30	362	17	101	298	7
Eteone longa	47	194	110	50	81	50	20	111	60
Harmothoe extenuata	141	189	61	54	215	87	101	115	27
Sthenelais limicola	372	187	40	47	472	17	151	381	10
Glycera dibranchiata	1,117	1,287	40	187	2,177	147	610	1,647	0
Goniadella gracilis	1,477	107	17	110	1,457	600	737	237	10
Nephtys bucera	1,017	188	30	27	1,148	200	507	468	30
Nephtys incisa	597	1,990	1,980	267	340	130	47	1,700	710
Nephtys picta	538	121	0	27	632	44	291	324	0
Nephtys (*Aglaophamus*) *circinata*	280	194	0	20	454	10	150	314	0
Order Capitellida									
Capitella capitata	34	6,145	5,028	20	1,131	0	1,027	5,131	21
Mediomastus ambiseta	546	7,334	6,430	380	1,070	320	308	2,242	5,010
Travisia carnea	137	71	0	0	208	24	48	136	0
Order Spionida									
Spio filicornis	349	862	51	440	720	87	228	889	7
Prionospio steenstrupi	1,165	2,780	610	1,460	1,875	977	944	1,774	250
Polydora ligni	228	208	81	40	315	20	161	211	44
Spiophanes bombyx	9,511	9,080	460	590	17,541	400	3,901	14,120	170
Paraonis gracilis	54	1,128	1,097	14	71	10	24	838	310
Aricidea catherinae	924	401	47	74	1,204	590	217	511	7
Order Eunicida									
Lumbrinerides acuta	351	80	10	10	411	287	107	27	10
Lumbrineris fragilis	622	594	67	310	839	490	278	428	20
Lumbrineris tenuis	564	1,537	600	410	1,091	410	327	1,234	130
Ninoe nigripes	344	1,484	470	300	1,058	340	120	1,168	200
Drilonereis longa	222	351	130	100	343	48	107	368	50
Order Magelonida									
Magelona riojai	238	7	0	0	245	10	88	147	0
Order Cirratulida									
Tharyx acutus	19,048	17,927	7,880	6,680	22,415	14,070	8,381	13,304	1,220
Tharyx annulosus	748	2,957	1,540	860	1,305	310	247	2,918	230
Caulleriella killariensis	297	97	10	10	374	37	190	167	0
Cossura longocirrata	40	370	400	10	0	0	0	260	150
Order Terebellida									
Ampharete arctica	322	224	67	130	349	57	107	365	17
Asabellides oculata	1,712	3,370	1,010	120	3,952	81	801	4,090	110
Order Flabelligerida									
Pherusa affinis	572	2,707	2,310	380	589	110	211	1,638	1,320
Phylum Arthropoda	4,230	1,340	380	270	4,920	410	1,740	3,120	300
Class Crustacea	4,230	1,340	380	270	4,920	410	1,740	3,120	300
Order Isopoda									
Edotea triloba	150	240	30	40	320	10	100	260	20

Table 1.—*Continued.*

Taxonomic group	Depth (m)		Sediment organic level			Sediment type			
	0–24	25–49	High >5%	Medium 3-5%	Low <3%	Very coarse-coarse sand	Medium sand	Fine-very fine sand	Coarse-medium silt
Order Amphipoda									
Ampelisca verrilli	810	0	0	0	810	0	140	670	0
Unciola irrorata	280	450	20	80	630	180	190	360	0
Pseudunciola obliquua	640	10	0	0	650	60	280	310	0
Protohaustorius deichmannae	920	0	0	0	920	0	370	550	0
Protohaustorius wigleyi	520	0	0	0	520	70	240	210	0
Leptocheirus pinguis	0	330	290	0	40	0	10	60	260
Rhepoxynius epistomus	350	60	0	30	380	10	160	240	0
Order Mysidacea									
Neomysis americana	200	0	10	10	180	0	50	140	10
Order Decapoda									
Crangon septemspinosa	160	40	0	20	180	20	70	110	0
Cancer irroratus	200	210	30	90	290	60	130	210	10
Phylum Echinodermata	350	310	0	0	660	20	240	400	0
Class Echinoidea	350	310	0	0	660	20	240	400	0
Echinarachnius parma	350	310	0	0	660	20	240	400	0

REPRODUCTION AND GROWTH: The Cerianthidae are protandrous hermaphrodites. The young sea anemone lives as a ciliated ball, unattached and free-swimming. During the *Edwardsia* stage, the larva usually settles and attaches to a variety of surfaces, develops tentacles, and adopts a benthic existence (Barnes 1963; Gosner 1971).

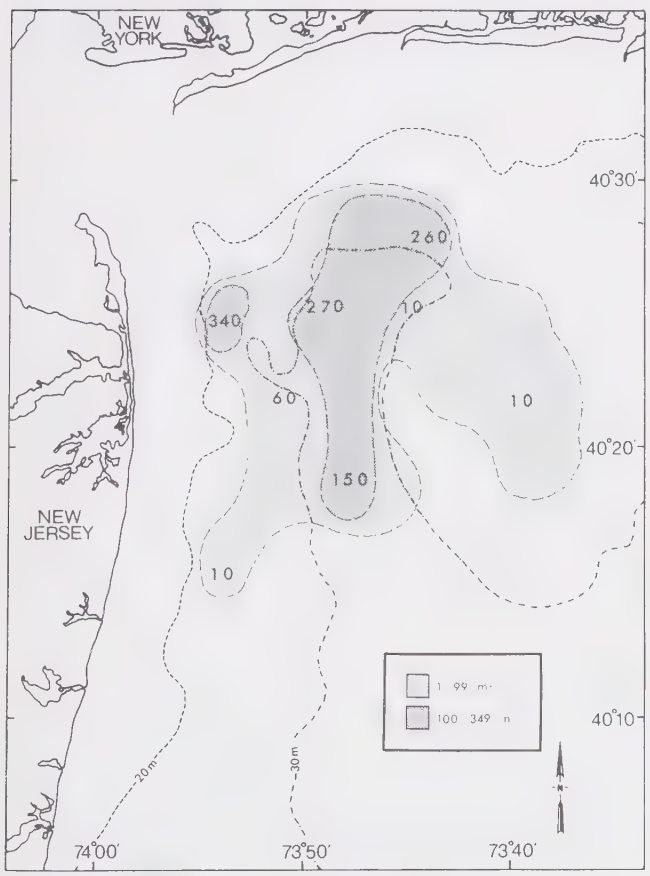

Figure 13.—Distribution and abundance of *Ceriantheopsis americanus* in the New York Bight apex.

Hyman (1940) stated that the life span of species of *Cerianthus* could range from 10 to 40 yr. Attempts at determining growth rates in the New York Bight apex have been unsuccessful (Fallon).[5]

Phylum Phoronida

Phoronis architecta (Andrews, 1890)

DESCRIPTION: Slender, flesh colored, wormlike tube dwellers; adults reach 50 mm in length. No annulations or setae present on the body; at the anterior end, the lophophore, two parallel horseshoe-shaped ridges, bears tentacles and a central mouth. The cylindrical, straight tube, more than twice as long as the worm itself, is produced as a chitinous secretion, and, being intially sticky, becomes covered with sand (Gosner 1971). Emig (1969, 1971) has synonymized *Phoronis architecta* with *Phoronis psammophila* Cori, but this synonomy has been the subject of debate. A count of longitudinal muscle bundles is the only method of positively separating *P. architecta* from *P. psammophila* (Paine 1961).

DISTRIBUTION: Both coasts of North America (Emig 1969); Florida Gulf coast to Biscayne Bay (Paine 1961); Gulf of Mexico (Louisiana and Texas) (Hedgpeth 1954).

HABITAT: Gosner (1971) reported the species as being found on sandy substrata from the lower littoral to depths of at least 18 m. Stancyk et al. (1976) stated that *P. architecta* occurred from sand to mud, from the intertidal to depths of 4 m. Wass (1972) reported densities of 90 individuals/m^2 in Chesapeake Bay. He also reported their occurrence in polyhaline waters with salinities as low as 18‰. Boesch (1973), however, believed *P. architecta* may occur in much higher densities than reported by Wass (1972) in Chesapeake Bay.

In the New York Bight apex, *P. architecta* occurred in depths ranging from 17 to 37 m. The species was collected from all sediment types but was most common in fine-sand, high organic areas, where densities reached 290 individuals/m^2 (Fig. 14; Table 1).

[5]Phillip Fallon, Equitable Environmental Health, 333 Crossways Park Drive, Woodbury, NY 11797, pers. commun. April 1979.

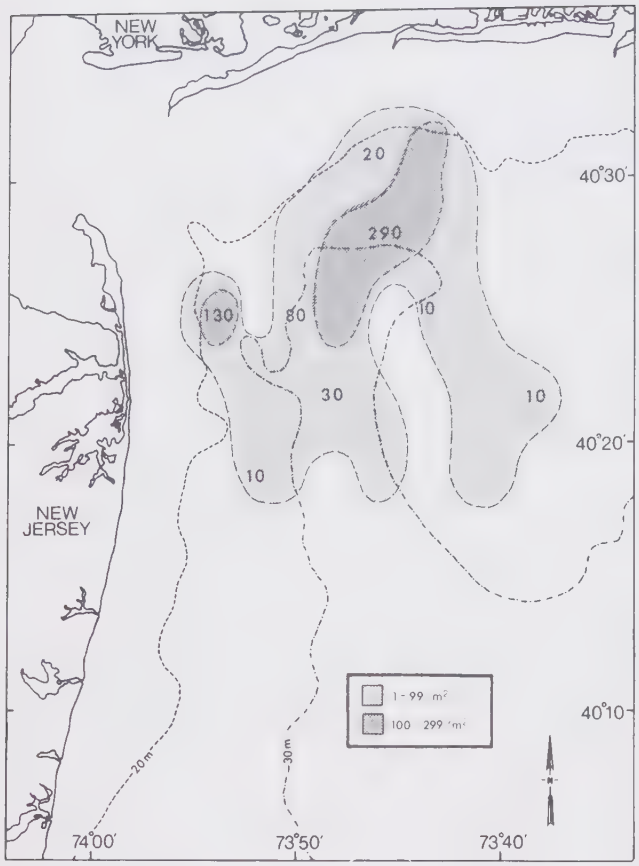

Figure 14.—Distribution and abundance of *Phoronis architecta* in the New York Bight apex.

FEEDING ECOLOGY: Phoronids, like other lophophorates, are ciliary mucous suspension feeders, subsisting on plankters or detritus fragments (Gosner 1971).

REPRODUCTION AND GROWTH: *P. architecta* has been regarded as a protandric hermaphrodite, but Hyman (1959) has questioned this view. Fertilization is external. No brooding occurs, with eggs hatching as an actinotroch larva (Gosner 1971). Typical actinotroch larvae were taken in plankton tows in Florida waters by Paine (1961) in December and February–August when towing was discontinuous. Adults reared in November had ova floating in their coelomic spaces, indicating a long, if not continuous, breeding season. Davis (1950) also collected actinotrochs in Florida in December and September and Hedgpeth (1954) recorded their presence during winter months in Louisiana and Texas.

After several weeks of a free-swimming planktonic existence, the actinotroch undergoes a rapid metamorphosis and sinks to the bottom, where it secretes a tube and begins its adult existence (Barnes 1963).

Phylum Mollusca

Class Gastropoda

***Nassarius trivittatus* (Say, 1822)**

DESCRIPTION: 1.9 cm in length; rather light shelled, 8–9 whorls, nuclear whorls smooth. Whorls in spire with 4–5 rows of strong, distinct beads. Color light ash to yellowish gray (Abbott 1974). The Nassariidae are gregarious, often occurring in great numbers (Abbott 1968).

DISTRIBUTION: Newfoundland to off northeast Florida (Abbott 1974).

HABITAT: Common from shallow water to about 82 m (Abbott 1974). Franz (1976) stated that *Nassarius trivittatus* is characteristic of the medium sand community in Long Island Sound. However, *N. trivittatus* has also been recorded in muddy sediments in Delaware Bay (Kinner et al. 1974) and in high silt-clay sediments in northwestern Buzzards Bay (Driscoll and Brandon 1973).

Nassarius trivittatus was the only abundant gastropod, occurring in numbers up to 20/m², collected in the New York Bight apex. It was found in depths of 11–27 m and was most characteristic of low organic fine sands (Fig. 15; Table 1).

FEEDING ECOLOGY: *N. trivittatus*, as all nassa snails (Nassariidae), is one of the most active and responsive scavengers among marine invertebrates. It has a keen ability to detect the products of chemical decomposition of dead flesh. Within a few seconds of sensing such a stimulus, the snail heads directly for its source. Nassas eat decaying fish and invertebrates; polychaete egg masses; eggs of the moon snail, *Lunatia heros*; benthic diatoms; and detritus on the sediment surface (Clarke 1956; Scheltema 1964; Abbott 1968). They, in turn, are preyed upon by fish such as haddock, *Melanogrammus aeglefinus* (Wigley 1956).

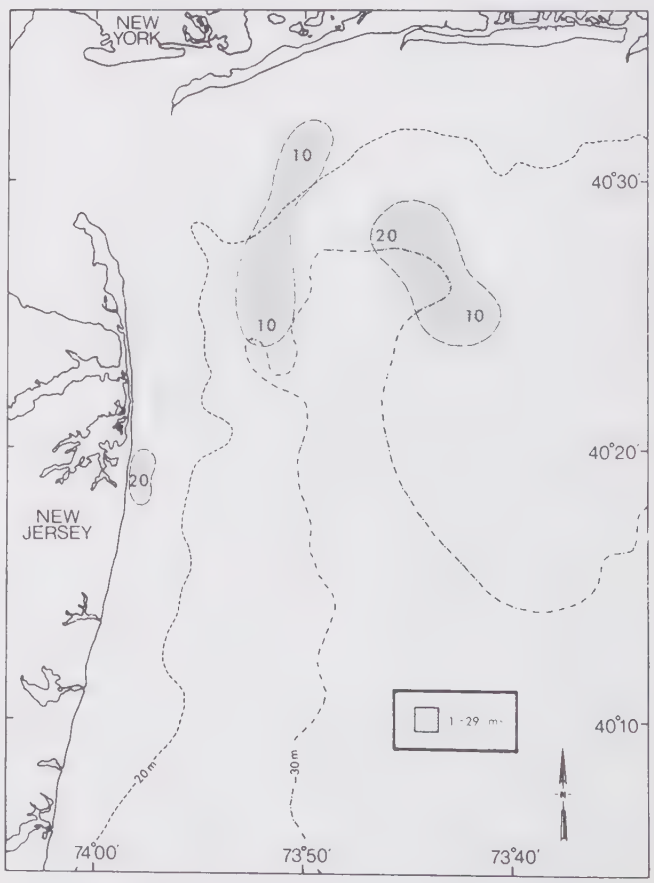

Figure 15.—Distribution and abundance of *Nassarius trivittatus* in the New York Bight apex.

REPRODUCTION AND GROWTH: Sexes are separate, with shells of males usually being smaller. Egg capsules, containing about 50 eggs, are laid in rows on algae, shells, stones, or sometimes on the underside of moon snail "sand collar" egg masses (Abbott 1968, 1974). In deeper waters of the continental shelf, *N. trivittatus* spawn during May and June when seawater temperatures are between 8° and 13°C. Intertidally, at Barnstable Harbor, Mass., spawning began in early May when seawater temperatures rose rapidly from about 9° to 15°C (Scheltema and Scheltema 1965). Pechenik (1978) reported spawning in the laboratory to occur at 7.4°C in December. Egg cases have been observed by Scheltema and Scheltema (1965) in Barnstable Harbor in early autumn. After about 1 wk at room temperature in the laboratory, 225 μm long free-swimming veliger larvae emerged from egg capsules. Under favorable conditions of laboratory culture, metamorphosis into snails occurred at 22 d following emergence, with most specimens between 0.9 and 1.1 mm in length at this stage.

ADDITIONAL INFORMATION: Unlike many marine snails, nassas are attracted toward light (Abbott 1968).

Class Bivalvia

***Nucula proxima* Say, 1822**

DESCRIPTION: Atlantic nut clam; 0.6 cm in length, obliquely ovate, smooth. Color greenish gray with microscopic, embedded, axial gray lines and prominent, irregular, brownish concentric rings (Abbott 1974).

DISTRIBUTION: Nova Scotia to Florida and Texas; Bermuda (Abbott 1974).

HABITAT: Common in mud and sand, 0.9–30 m (Abbott 1968, 1974). Menzel (1964) listed *Nucula proxima* as a subtidal mud dweller occurring at salinities >25‰ in Florida. In Virginia, it occurs in sand to silty sand, at salinities >20‰ (Wass 1965). In samples taken near the mouth of Delaware Bay, *N. proxima* was among the three most abundant species collected; there, it was a member of a high silt-clay facies (>50% silt-clay) (Kinner et al. 1974). In the soft-bottom community of Buzzards Bay, Mass., *N. proxima* and *Nephtys incisa* dominated the fauna (Sanders 1958, 1960; Driscoll and Brandon 1973).

In a prior apex study, Pearce (1972) found *N. proxima* in greater abundance around sludge deposits than in natural communities. In the present study, *N. proxima* was again clearly most abundant in high organic fine sands and silt, although it was present in all sediment types. It occurred in numbers between 10 and about 22,000/m^2 and was by far the most abundant bivalve collected (Fig. 16; Table 1).

FEEDING ECOLOGY: *Nucula* spp. are sporadically mobile, normally lying at or just below the sediment surface feeding on the sediment just beneath them by means of long appendages derived from the palp. Only fine particles are moved along the groove to the palps where they are passed by cilia to the mouth. *Nucula* spp. are thus selective deposit feeders (Abbott 1968; McCall 1977).

Nucula spp. are a source of food for several species of bottom-feeding fish (Abbott 1968).

REPRODUCTION AND GROWTH: *N. proxima* exhibits no egg protection; larvae are lecithotrophic with a short pelagic development. Time to maturity is unknown (Chanley 1969; Scheltema 1972).

The size, shape, and coloration of this species vary according to substrate and water temperature. Among the probable forms are: *truncula* Dall, 1878; *ovata* Verrill and Bush, 1898; and *annulata* Hampson, 1971 (Abbott 1974).

Allen (1953, 1954) showed precise year-classes for five English species of this genus. He postulated that the largest individual in his samples was 12–20 yr old, depending on the species, and that the yearly increment in length varied from 0.94 to 1.01 mm, regardless of species or age. Blake and Jeffries (1971) grew *N. proxima* in tanks. They estimated 2.0 mm/yr growth for the first size-class of *N. proxima* and 1.0 mm/yr for the second size-class. These estimates are greater than Carey's (1962) estimate of 0.38 mm/yr for *N. proxima* in Long Island Sound, but are similar to Allen's (1953, 1954) estimates for British species.

ADDITIONAL INFORMATION: Levinton (1972) found *N. proxima* in Long Island Sound to be randomly distributed with a tendency toward aggregation in some cases. Juveniles were distributed essentially the same as adults. It is argued that the lack of defense mechanisms, the instability of the substrate, the small "reach" of the feeding organ, and the lack of advantage of territoriality to a mobile deposit feeder, all contribute to the observed random patterns of *N. proxima*.

In experiments using a radioactive tracer, cadmium–109 (^{109}Cd), Jackim et al. (1977) showed that an increase in temperature or a decrease in salinity increased the ^{109}Cd uptake rate of *N. proxima*.

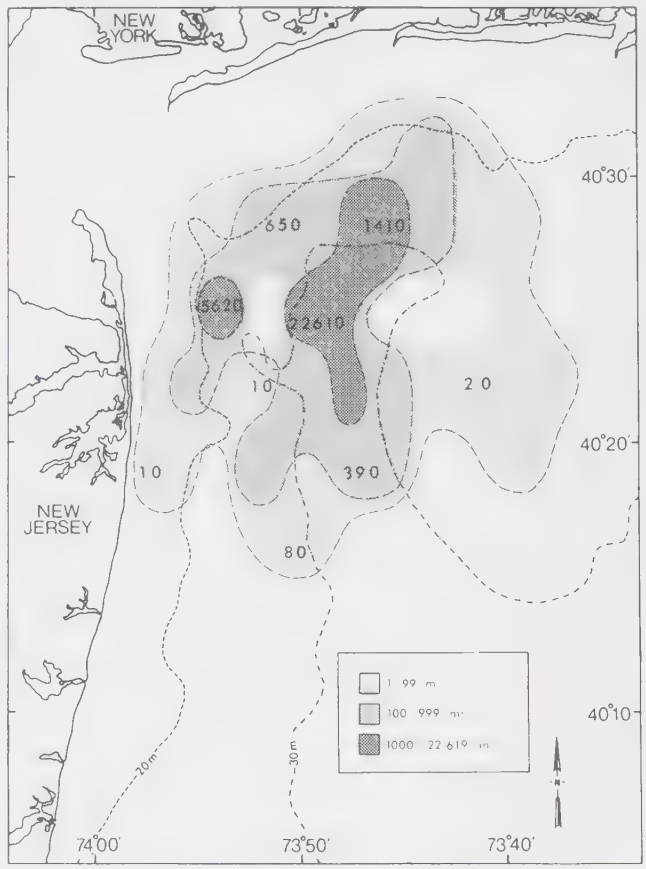

Figure 16.—Distribution and abundance of *Nucula proxima* in the New York Bight apex.

The infaunal filter feeder *Mulinia lateralis* accumulated about five times more ^{109}Cd than the deposit feeder *N. proxima*. Evidence presented indicated that early uptake rates might be indicative of subsequent acquired body burdens after long-term exposure.

***Astarte castanea* (Say, 1822)**

DESCRIPTION: Commonly called the smooth *Astarte*; 2.5 cm in length and height, trigonal in shape, quite compressed. Shell almost smooth, except for weak, low concentric lines. Color a glossy light brown (Abbott 1974).

DISTRIBUTION: Nova Scotia to off New Jersey (Abbott 1974). Miner (1950) and Gosner (1971) recorded the range to Cape Hatteras.

HABITAT: Characteristic of coarse sand (Franz 1976); in mud, in fairly shallow water to 30 m (Abbott 1968). Gosner (1971) reported it in depths to 119 m.

Astarte castanea was collected in depths up to 25 m in the New York Bight apex. It occurred in all grades of sand but was most abundant in coarse sands. It was found only in low organic areas (Fig. 17; Table 1).

FEEDING ECOLOGY: *A. castanea* has no siphons and is a suspension feeder (Sanders 1956; Abbott 1968).

Astarte castanea is eaten especially by haddock, other groundfishes, and predator snails. According to Wigley and Theroux (1965), *Astarte* sp. is the third most important mollusk, behind *Nucula tenuis* and *Cerastoderma pinnulatum*, as food for haddock.

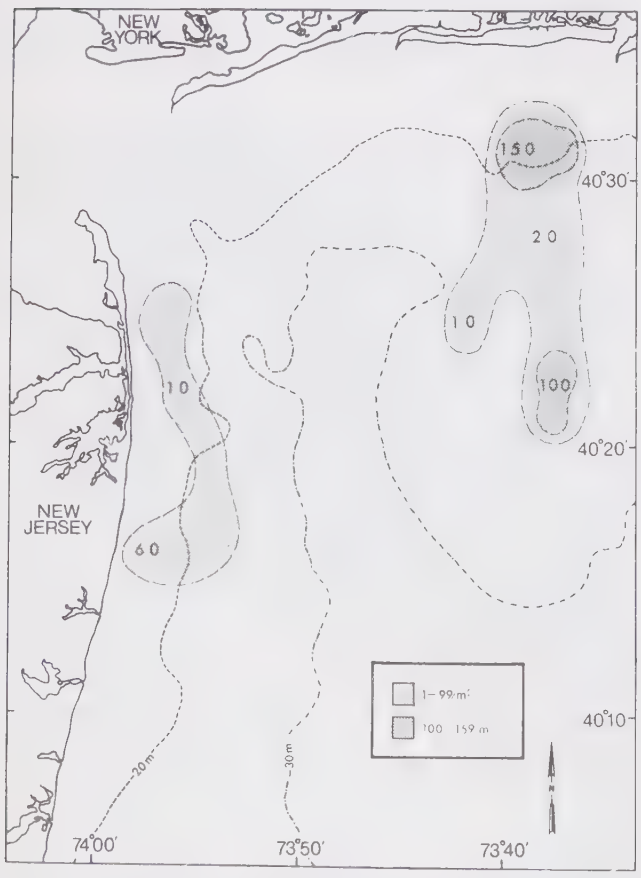

Figure 17.—Distribution and abundance of *Astarte castanea* in the New York Bight apex.

REPRODUCTION AND GROWTH: Sexes are separate, with male and female clams occurring in equal numbers (Abbott 1968). *Astarte castanea* begins producing mature viable gametes when 15–16 mm in length. Production of gametes is neither seasonal nor cyclic since mature gametes have been found in abundance in these animals throughout the year (Ruddell 1977).

***Arctica islandica* (Linné, 1767)**

DESCRIPTION: The ocean quahog or mahogany clam; 8–13 cm in length, almost circular in outline, with a rather strong, porcelaneous shell which is commonly chalky. *Arctica islandica* is the only living species in its family (Arcticidae); there are numerous fossil species. Superficially, *A. islandica* resembles the hard clam, *Mercenaria mercenaria*, however, the dark brown to black periostracum (horny external covering) of *A. islandica* is the most obvious distinguishing characteristic (Abbott 1974).

DISTRIBUTION: Newfoundland to off North Carolina, northern Europe, Iceland (Pratt 1973; Abbott 1974).

HABITAT: The ocean quahog is a common, commercially dredged species, most abundant on silty sand and stable fine sand (Turner 1949; Parker and McRae 1970), but occasionally found on silt-clay bottoms (Arcisz and Sandholzer 1947; Bureau of Commercial Fisheries 1970[6]). Results of National Marine Fisheries Service surveys show that it is found at depths from 18–27 m to the shelf edge off New Jersey and the Delmarva Peninsula, and in scattered patches from 37 m off Virginia; it is also landed in small quantities in southern New England. While the shoreward boundary has been well established, distribution and abundance offshore is not well known. High temperatures limit the shoreward distribution of *A. islandica*; in the southern part of its range it is rarely found within the 17.5°C maximum isotherm as drawn by Walford and Wicklund (1968). In the laboratory, the upper lethal limit for fully acclimated Rhode Island animals is about 24°C; the ocean quahog is active at temperatures as low as 0°C, but activity decreases above 18°C (Saila and Pratt 1973).

Almost all *A. islandica* collected in New York Bight apex grab samples were juveniles. They were taken from depths between 23 and 37 m. *Arctica islandica* were most common in fine sands but occurred in low numbers in silt. Highest total numbers were in high organic sediments with fewer in medium and low organic areas (Fig. 18; Table 1).

FEEDING ECOLOGY: *A. islandica* has very short siphons and is a shallow burrower (Saleuddin 1964). It is a filter feeder with the capacity to filter large and variable amounts of water (Winter 1969). Merrill et al. (1969) stated that many dredged quahog shells have been found drilled by predatory, naticid gastropods.

Caloric values of Canadian specimens follow a seasonal trend, with a summer maximum and winter minimum (4,276 to 3,684 cal/g dry weight) (Tyler 1973).

REPRODUCTION AND GROWTH: The reproduction of an ocean quahog population off Rhode Island was studied by

[6]Bureau of Commercial Fisheries. 1970. Ocean quahog survey. Cruise Report, *Delaware II* Cruise 70-5. National Marine Fisheries Service, Exploratory Fishing and Gear Research Base, Woods Hole, Mass., 6 p.

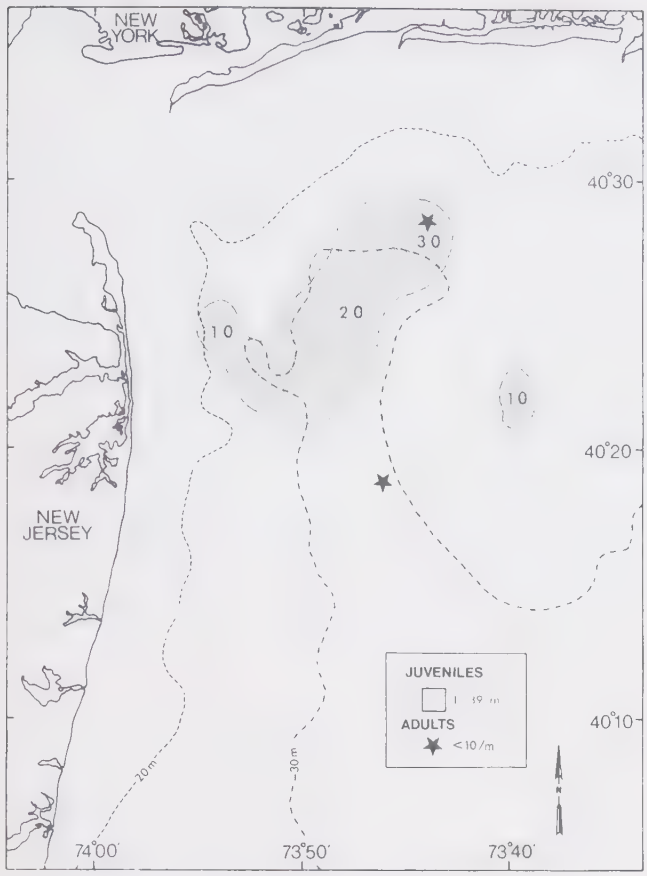

Figure 18.—Distribution and abundance of *Arctica islandica* in the New York Bight apex.

Loosanoff (1953). Rapid gonad growth took place during spring and spawning began at a temperature of 13.5°C in late June or early July and continued into October. Landers (1973) found that the planktonic larvae reared at 10°C metamorphosed in about 60 d when they were about 200 μm in length. His attempts to ripen clams out of season met with limited success.

Merrill et al. (1969) stated that it is not possible to estimate the age of adults. However, obvious annual rings indicate that commercial size individuals are over 10 yr old. Thompson[7] suggested that this species may even live over 60 yr, an estimate based on refined growth ring analysis.

ADDITIONAL INFORMATION: In laboratory tanks and in the sea, it has been shown that *A. islandica* can exhibit a high degree of respiratory independence under hypoxic conditions. Under these conditions, the periods the clam spends at the surface alternate with periods when it is buried several centimeters below the surface of the sand, during which the animal respires anaerobically. There is no obvious rhythmicity to this behavior; the durations of periods spent beneath the surface are variable, even in the same animal, but they normally last between 1 and 7 d. As in other species studied, respiratory independence in *A. islandica* increases markedly with increasing body size and can also be modified by temperature and physiological condition (Taylor and Brand 1975a, b; Taylor 1976).

The ocean quahog industry has developed more slowly than that of the surf clam, *Spisula solidissima*. It was not until the 1970's that a vigorous commercial ocean quahog fishery developed, primarily to supplement diminishing supplies of the more desirable surf clams.

***Cerastoderma pinnulatum* (Conrad, 1831)**

DESCRIPTION: Northern dwarf cockle; 0.6–1.3 cm in length, thin, with 22–28 wide, flat ribs which have delicate, arched scales on the anterior slope of the shell. Exterior cream colored, interior glossy and white (Abbott 1974). Cockles are active animals, with larger species able to leap several inches off the bottom (Abbott 1968).

DISTRIBUTION: Labrador to off North Carolina (Abbott 1974).

HABITAT: Because of their very short siphons, cockles must live near the surface of the substrate and consequently are affected by shifting sands and, in shallow water, by great temperature changes. They are commonly collected from 6 to 183 m (Abbott 1968, 1974). Franz (1976) stated that *Cerastoderma pinnulatum* is characteristic of coarse sand in Long Island Sound.

In the apex of the New York Bight, *C. pinnulatum* was collected from depths of 22–37 m. It occurred in all sediment types but was most common in high organic fine sands (Fig. 19; Table 1).

FEEDING ECOLOGY: *C. pinnulatum* possesses short separate siphons and feeds on organic matter suspended in water (Sanders

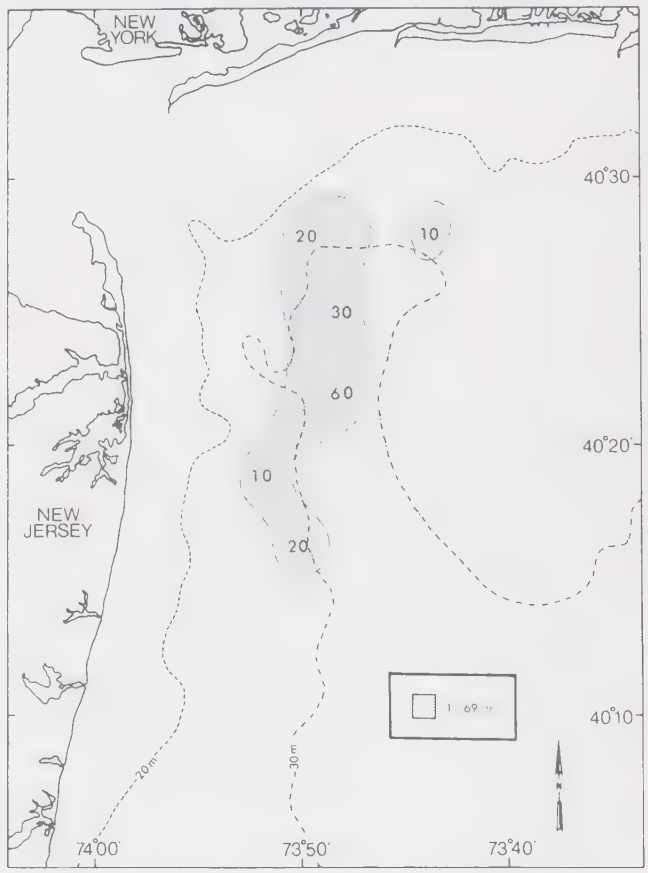

Figure 19.—Distribution and abundance of *Cerastoderma pinnulatum* in the New York Bight apex.

[7]Ida Thompson, Princeton University, Princeton, NJ 08540, pers. commun. October 1979.

1956). Wigley (1956) reported that *C. pinnulatum* is the main prey item of haddock.

REPRODUCTION AND GROWTH: Cockles grow steadily except during the coldest months. Most are hermaphroditic (Abbott 1968).

Pitar morrhuanus Linsley, 1848

DESCRIPTION: Morrhua Venus clam; 2.5–3.8 cm in length, oval-elongate, moderately plump; numerous heavy lines of growth. Color dull-grayish to brownish red (Abbott 1974).

DISTRIBUTION: Gulf of St. Lawrence to North Carolina (Abbott 1974).

HABITAT: Fairly common; dredged from sand at 6–183 m (Abbott 1968).

In the New York Bight apex, *Pitar morrhuanus* was collected from depths between 19 and 37 m. It inhabited all sediment types but was most common in fine sands; total counts in high and low organic areas were almost equal, however, the largest concentration of *P. morrhuanus* was found at a high organic station. *Pitar morrhuanus* was the third most abundant bivalve, after *Nucula proxima* and *Tellina agilis*, collected in the Bight apex (Fig. 20; Table 1).

FEEDING ECOLOGY: *P. morrhuanus* is a suspension feeder, drawing in food-laden seawater. Young Veneridae, including *P. morrhuanus*, are important food sources of both the blue, *Callinectes sapidus*, and green, *Carcinus maenas*, crabs and the drilling moon snails, *Polinices* spp. (Abbott 1968).

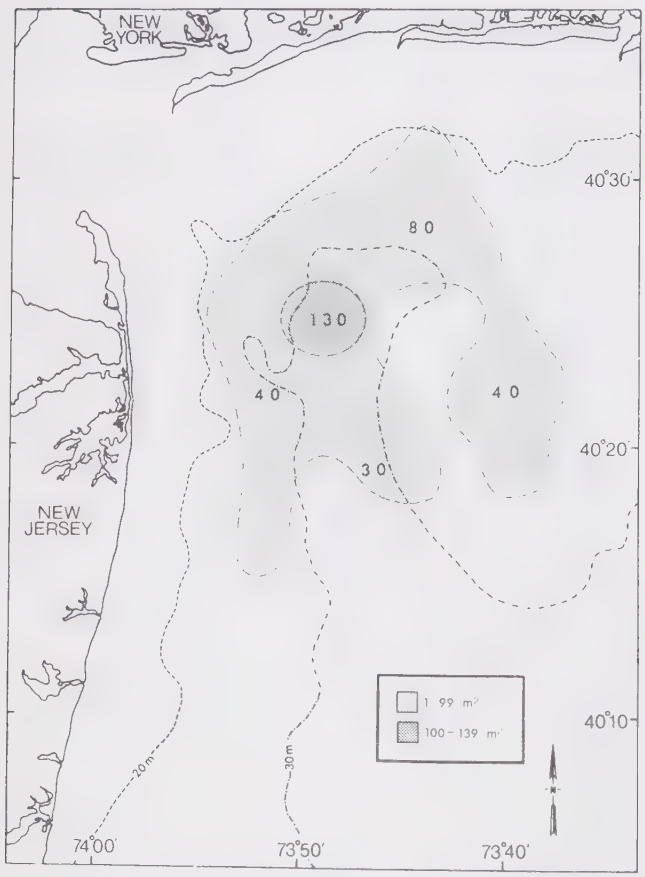

Figure 20.—Distribution and abundance of *Pitar morrhuanus* in the New York Bight apex.

REPRODUCTION AND GROWTH: The Veneridae are prolific and are adapted to survival under difficult conditions. Sexes are separate and fertilization is external (Gosner 1971). In general, they spawn when the tide is out and usually during a part of the month when the tidal fluctuation is small. The larvae swim and crawl over the bottom until a suitable mud-covered, hard surface is found. They then secrete a byssus and remain attached for about a week until siphons develop (Abbott 1968).

Spisula solidissima (Dillwyn, 1817)

DESCRIPTION: Atlantic surf clam; commercial size individuals are approximately 12–15 cm in length, the largest bivalve in the Middle Atlantic Bight. Shell is strong, oval and smooth except for light irregular growth lines; color is yellowish white with a thin yellowish brown periostracum (Abbott 1974). Over 70% of all clams harvested in North America are the Atlantic surf clam from the Middle Atlantic Bight.

DISTRIBUTION: Nova Scotia to South Carolina (Abbott 1968).

HABITAT: The surf clam is common below the low water mark on ocean beaches. After violent winter storms, they are cast ashore in numbers estimated as high as 50 million clams along a 10 mi stretch (Abbott 1974). NMFS surveys show *Spisula solidissima* to be abundant north of Hudson Channel in depths of not more than 18 m. It also occurs on coarse bottoms of Georges Bank. From New Jersey south, populations extend to depths of 46 m. Very dense beds at an average depth of 12 m occur off Point Pleasant and Cape May, N.J. The beds of the Delmarva Peninsula form a bank 24–28 km off the coast at a depth of 27–35 m, and currently support the bulk of the U.S. fishery.

Abundance of this clam is strongly correlated with coarse sediments. Parker (1967) and Parker and Fahlen (1968) reported that catches in gravel were 2.5 and 2 times those in sand, and 5.5 and 3 times those in silt-clay. Their size and burrowing ability give them advantages over other bivalves in unstable sediments.

In the New York Bight apex, primarily juvenile *S. solidissima* were collected in depths between 9 and 25 m. They were most abundant in medium and fine low organic sands. Very few occurred in coarse sand and none occurred in silt or high organic areas (Fig. 21; Table 1).

Wass (1965) stated that *S. solidissima* only occurs at salinities >28‰ under natural conditions, but may be able to tolerate much lower salinities. Schechter (1956) placed the minimum tolerance of both eggs and sperm of *S. solidissima* at "40% seawater" or about 15‰. Eggs in the polar body stage, however, disintegrate at this salinity. In laboratory experiments, Castagna and Chanley (1973) found that some surf clams survived direct transfer to salinities between 15 and 30‰. After acclimation, many survived salinities as low as 10‰. The authors believe that *S. solidissima* does not inhabit the lower extremes of its potential salinity range because of larval predation, not salinity intolerance. They state that when larvae of this species colonize inshore areas, they rarely develop because of intense predation by crabs, carnivorous gastropods, and bottom-feeding fish; this prevents the establishment of permanent populations of *S. solidissima* in estuarine areas.

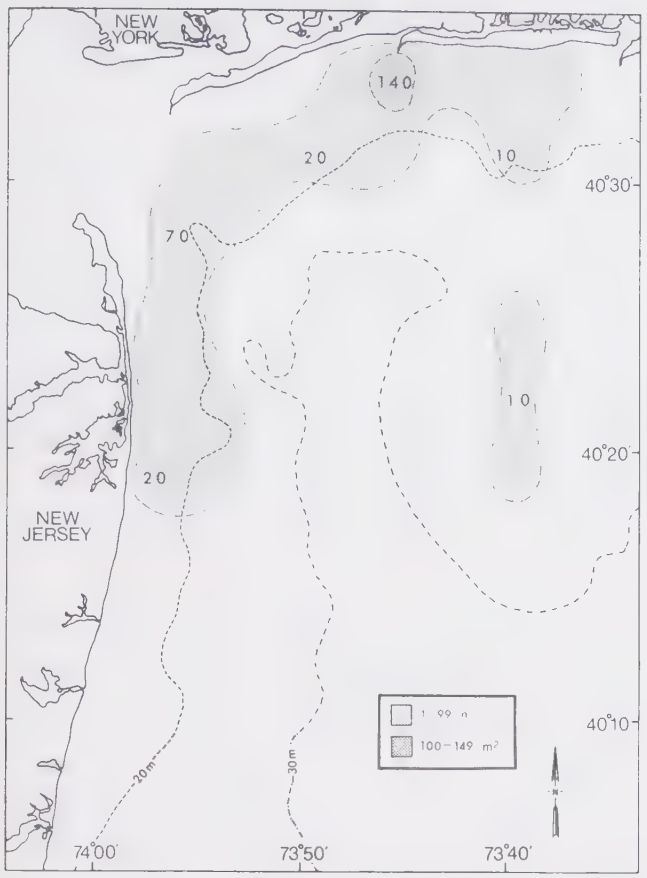

Figure 21.—Distribution and abundance of *Spisula solidissima* in the New York Bight apex.

FEEDING ECOLOGY: *S. solidissima* is a filter feeder; it lies near the sediment surface and extends short, fused siphons into the water. Stephens and Schinske (1961) reported that their experiments with *S. solidissima* indicate that, during a 16-h period, the removal of the amino acid glycine from solution took place in the mantle cavity of adult surf clams with an efficiency of 87%; the ecological significance of this remains to be fully examined. The food of larval *S. solidissima* consists of diatoms, green algae, and naked flagellates (Hirano and Oshima 1963).

Surf clams, when under stress of crowding or predator attack, may come to the surface and perform leaps of several feet. Predators of this clam include the moon snails, *Lunatia heros*, in deep water, and *Polinices duplicatus*, in shallow water. Smaller surf clams provide food for fish, including cod and haddock, and for diving ducks (Saila and Pratt 1973). Franz (1977) compared the size distribution of *S. solidissima* valves with and without bore holes of *L. heros*. In specimens collected off Long Island, he found that predation by *L. heros* is largely limited to clams <80 mm in size and under 5 yr of age. However, older and larger clams are not completely immune to attack, since bored valves to 160 mm in length were occasionally observed.

Thorson (1957) stated that communities where *Spisula elliptica* is dominant may have extremely high productivities; in European waters, these areas are growth centers for young flounder. The yield to man of *S. solidissima*-dominated bottoms in terms of fish food is probably lower in the Middle Atlantic Bight because much of the area where *S. solidissima* is most abundant is south of the range of the mass marketed groundfish such as cod, haddock, and yellowtail flounder.

REPRODUCTION AND GROWTH: According to Ropes (1968), sexes are separate in *S. solidissima* and it has been reported that two annual spawnings occurred in three successive years off New Jersey, a major one from mid-July to August and a minor one in mid-October to November. In a cool year (1965), a single spawning was observed during September and October (Ropes et al. 1969). Larvae took 19 d to reach setting size in the laboratory at 22°C (Loosanoff and Davis 1963).

Initial growth is rapid and clams can grow to 4.4 cm by the end of their first year (Yancey and Welch 1968). Clams reach commercial size of about 12.5 cm in 5–6 yr after which they grow at a much slower rate for as long as 17 yr. Maximum length is only 7.5–10 cm for specimens off Cape Cod but is about 17.5 cm for those off Long Island and to the south.

ADDITIONAL INFORMATION: The modern fishery which developed after World War II utilizes highly developed, efficient hydraulic dredges. Yearly landings of surf clam meats for 1978 off New Jersey totaled 6,904 t, which sold at a price of about $1,093/t (Current Fisheries Statistics 1978). This was a drop from 5 yr before when total New Jersey landings were 9,792 t, which sold for a low price of about $277/t (Current Fisheries Statistics 1973). Much of the stock in the New York Bight apex is closed to fishing by the U.S. Food and Drug Administration because of bacterial and chemical contamination.

The surf clam is particularly well adapted to withstand mechanical stress, however, little is known about its ability to withstand other types of stress, either as larvae or adults. For example, during the 1976 New York Bight oxygen depletion phenomenon, thousands of *S. solidissima* were found dead during surveys, with some recolonization by juveniles reported in the summer of 1977 (Steimle and Sindermann 1978; Steimle and Radosh 1979).

Tellina agilis Stimpson, 1857

DESCRIPTION: Northern dwarf tellin; 0.8–1.3 cm in length; moderately elongate, compressed, fairly fragile; glossy-white to rose externally with an opalescent sheen. External sculpture of faint, microscopic concentric, impressed lines (Abbott 1968, 1974).

DISTRIBUTION: Gulf of St. Lawrence to Georgia (Abbott 1974).

HABITAT: Common; in sandy mud, 0.9–45 m (Abbott 1968). In Long Island Sound, Franz (1976) found *Tellina agilis* to be characteristic of medium sand. In samples taken near the mouth of Delaware Bay, *T. agilis* was among the three most numerous species collected, occurring in the transition zone between pure sand and mud facies (Kinner et al. 1974). In Delaware's coastal waters, it was the most abundant and frequently occurring bivalve in clean medium-coarse sand (Maurer, Leathem, Kinner, and Tinsman 1979). The occurrence of *T. agilis* in large numbers throughout a wide sediment range indicates that it has a broad tolerance for sediment particle size.

Wass (1965) has determined that *T. agilis* prefers salinities $>18‰$ under natural conditions. However, in the laboratory, it tolerates a wide salinity range (2.5–30‰). In nature, it may not inhabit its potential salinity range because of biological interactions such as predation, competition from other species, or special environmental requirements, i.e., high levels of dissolved oxygen, low levels of suspended sediments, suitable bottom type, etc. (Castagna and Chanley 1973).

Tellina agilis was found at almost all stations sampled in the New York Bight apex. Although it tolerated a wide range of sediment types, it was most characteristic of fine or medium grain, low organic sands. *Tellina agilis* was the second most abundant bivalve in our samples, following *Nucula proxima* (Fig. 22; Table 1).

FEEDING ECOLOGY: Tellin clams have two long, slender siphons, which can be extended several times the length of the shell, permitting the clams to live well below the surface of the sand, while deposit feeding on the sediment surface. The large foot is suitable for rapid and deep burrowing and the clams travel extensively under the sand, both vertically and horizontally (Abbott 1968). Stomach analyses show that *T. agilis* feeds largely on diatoms and detritus (Sanders et al. 1962; Levinton 1972; Levinton and Bambach 1975). Kinner et al. (1974) stated that they may occasionally be suspension feeders. This dual feeding mechanism may explain the occurrence of *T. agilis* in a wide range of sediment types.

It has been found that the movement of siphons of *Tellina* spp. may attract visual predators such as the commercially important winter flounder, *Pseudopleuronectes americanus* (Gilbert 1970; Gilbert and Suchow 1977). Edwards et al. (1970) have shown that in Scotland, small flounder, *Pleuronectes platessa*, obtain a large part of their food by preying on siphons of *Tellina tenuis* da Costa, which can later be regenerated. However, more studies are needed to determine the importance of *T. agilis* siphons in the diet of young winter flounder.

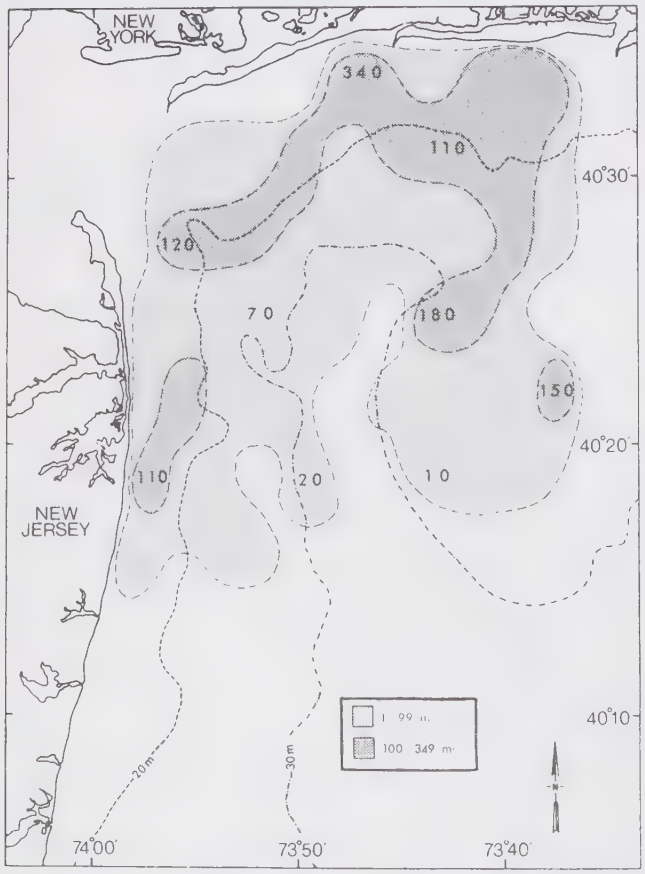

Figure 22.—Distribution and abundance of *Tellina agilis* in the New York Bight apex.

REPRODUCTION AND GROWTH: Sexes are separate and fertilization is external (Gosner 1971). The larvae of *T. agilis* are planktotrophic with a long pelagic development. Time to maturity is unknown (Sullivan 1948; Boss 1966).

Ensis directus Conrad, 1843

DESCRIPTION: Atlantic jackknife clam; up to 25 cm in length; six times as long as high, moderately curved with sharp edges. Shell white, covered with a thin, varnish-like brownish-green periostracum (Abbott 1974). In its undisturbed state, *Ensis directus* occupies a vertical position in its burrow with an inch or two of shell exposed. When disturbed, it burrows rapidly to safety propelling itself by releasing jets of water around the base of the foot; it is also a capable swimmer (Drew 1907; Abbott 1968).

DISTRIBUTION: Labrador to South Carolina, Florida (Abbott 1974).

HABITAT: Common on sand flats of New England, but subtidal beds in sandy mud at depths of 3–9 m are not uncommon (Abbott 1974). In Long Island Sound, Franz (1976) found *E. directus* to be characteristic of the medium sand assemblage. In Virginia, it is an intertidal and subtidal form found in waters above 20‰ salinity (Wass 1965). Under experimental conditions, however, Chanley (1969) found that *E. directus* could be acclimatized to survive at 7.5–28‰, however, a rapid salinity change of 15‰ within this range was lethal.

In the New York Bight apex, *E. directus* occurred in low abundance, 10/m^2, at each of six stations, in depths $\leq$28 m. It was present, almost exclusively, in low organic medium and fine sands (Fig. 23; Table 1).

FEEDING ECOLOGY: *E. directus* is a suspension feeder (Wigley 1968). It is a food item for man as well as for invertebrates. McDermott (1976) stated that *Cerebratulus lacteus* (a nemertean worm) feeds on *E. directus* by entering its burrow from below and engulfing the anterior end of the bivalve. This predation was observed from New Jersey to North Carolina. *Polinices duplicatus* (a moon snail) captures *E. directus* by approaching it below the surface of the substratum and irritating its lower portion so that the clam retreats upward. The snail then coats the razor clam with an envelope of slime which appears to have an anesthetic property. Successful capture probably depends on the ability of the snail to maintain contact with its prey until anesthesia has taken place (Turner 1955).

REPRODUCTION AND GROWTH: According to Williams and Porter (1971), planktonic juvenile *E. directus* occur abundantly from December to June in North Carolina. They exhibit long pelagic development with time to maturity unknown (Turner 1953).

ADDITIONAL INFORMATION: McCall (1977) characterized *E. directus* as an "equilibrium" species, i.e., it is present early in colonization, but remains at low and constant abundance. Relative to more opportunistic species, equilibrium species exhibit slow development, few reproductions per year, low recruitment, and low death rate.

Saila and Pratt (1973) stated that although the razor clam is abundant along the east coast, it has not been exploited commercially as on the west coast. Scattered fisheries for local markets in Massa-

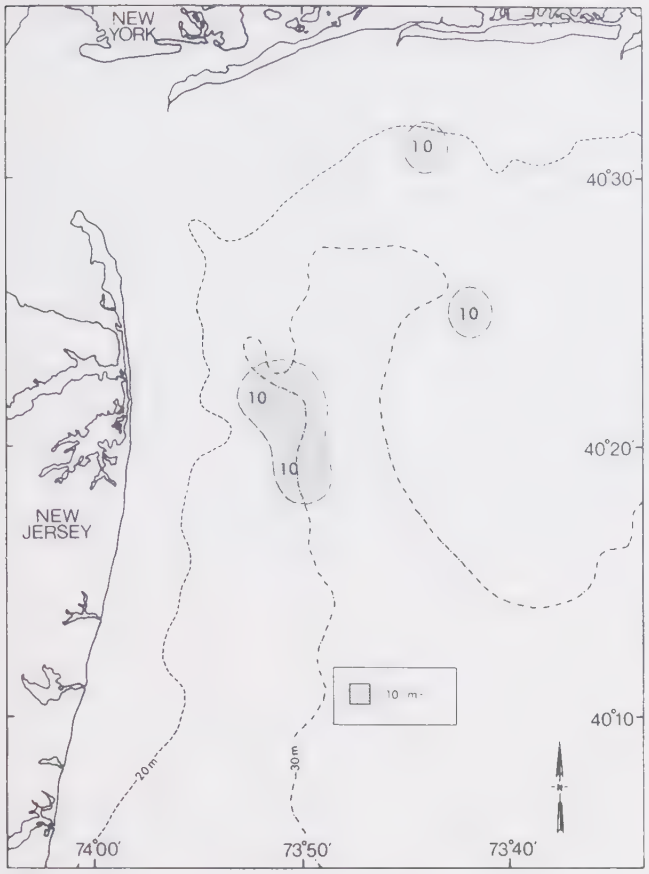

Figure 23.—Distribution and abundance of *Ensis directus* in the New York Bight apex.

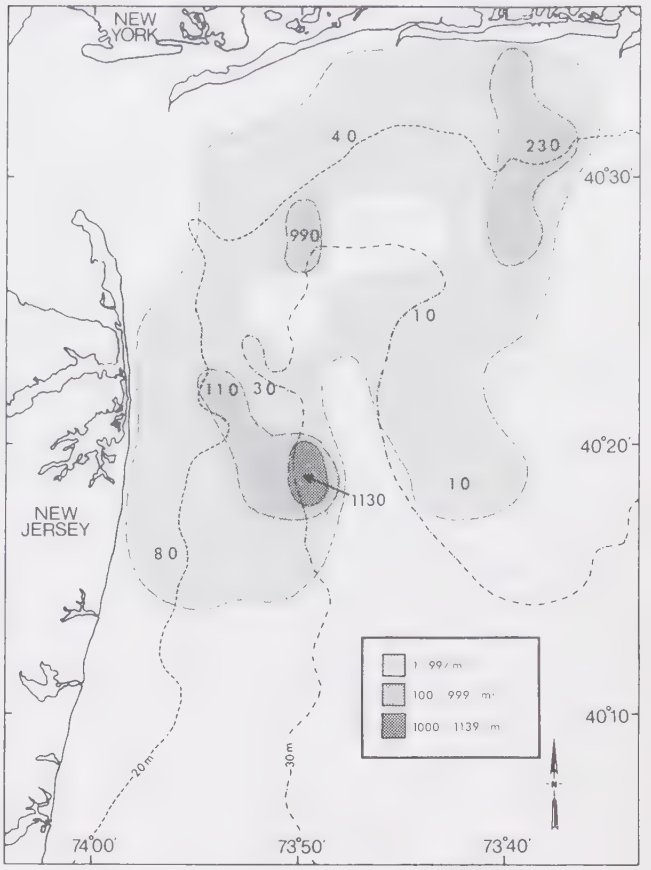

Figure 24.—Distribution and abundance of *Polygordius triestinus* in the New York Bight apex.

chusetts and New York and recreational clamming account for the east coast harvest.

Phylum Annelida

Class Polychaeta

Order Archiannelida

***Polygordius triestinus* Hempelmann, 1906**

DESCRIPTION: *Polygordius triestinus* is a member of a group called the archiannelids, a heterogeneous assemblage of small worms that have been considered either derivatives of several polychaete families or specialized relicts of the ancestral polychaete stock. *Polygordius triestinus*, adapted for interstitial life, is a very slender worm, lacking obvious external annulation, eyes, and setae. Its only appendages are two cylindrical tentacles projecting from the head and two cirri projecting from the pygidium. Gosner (1971) reported them to be ≤ 15 mm in length; Fauvel (1927) reported them reaching lengths up to 30 mm.

DISTRIBUTION: Very little is known about the distribution of this species, however, Gosner (1971) classified it as a Virginian species, occurring from Cape Cod to Cape Hatteras.

HABITAT: An unidentified species of *Polygordius* was the most abundant macrobenthic species in clean medium grain sand off the Delmarva Peninsula (Maurer et al. 1976). Figure 24 and Table 1 indicate that *P. triestinus* was generally associated with sandy (primary medium-grain) sediments with low to medium organic content in the New York Bight apex.

FEEDING ECOLOGY: The antennae of this genus are actively cast about in front of it as it crawls along, very much as in some of the spionid polychaetes. Similarly, *Polygordius* spp. are deposit feeders (Hermans 1969).

REPRODUCTION AND GROWTH: Fauvel (1927) believed *P. triestinus* to be hermaphroditic. However, hermaphroditism in this species is doubted by Schroeder and Hermans (1975) because they believe that the coexistence of eggs and sperm observed in a single individual by Hempelmann (1906) was the result of fertilization, as has been shown in another archiannelid, *Protodrilus* sp. by Jägersten (1952). Gosner (1971) also reported sexes to be separate in most archiannelids. Salensky (1907) pointed out that some species of *Polygordius* released their eggs by a breaking off of the posterior end of the spawning adult. He suggested that such behavior may represent the origin of epitoky and stolonization found in a number of polychaete families. MacBride (1914) and Hermans (1969) stated that *Polygordius* spp. exhibit the primitive pattern of polychaete development by producing well developed planktotrophic trochophore larvae.

Order Phyllodocida

Phyllodoce (*Anaitides*) *arenae* Webster, 1879

DESCRIPTION: An active, crawling, mucus-secreting form, which moves freely over the sediment surface or swims. Dorsal surface with dark transverse bands; length to 100 mm, width to 2.5 mm, segments to 200 (Pettibone 1963).

DISTRIBUTION: Maine to North Carolina (Gardiner 1975).

HABITAT: Coarse to muddy sand mixed with some shell fragments, intertidal to 195 m (Pettibone 1963; Gardiner 1975). In the New York Bight apex, *Phyllodoce arenae* occurred primarily in fine to medium, low organic sandy substrates and was sparsely represented in coarse sands, silt, and medium to high organic areas (Fig. 25; Table 1).

FEEDING ECOLOGY: Their active habits and well-developed eyes imply that all phyllodocids are carnivorous, but no form of prey or plant remains has ever been found in the gut of *P. arenae* (Pettibone 1963; Day 1967). A closely related species, *Phyllodoce maculata*, is predaceous, attacking and devouring other polychaetes and nemerteans, being itself protected, to some extent, by its abundant, offensive mucus (Pettibone 1963).

REPRODUCTION AND GROWTH: *P. arenae* has been found swarming at the water surface in June, July, and August in Woods Hole, Mass., however, they are not epitokous. Many phyllodocids lay their greenish-colored eggs in gelatinous masses. The larvae of *P. arenae* may have a long pelagic existence as do those of several other species of *Phyllodoce* (Thorson 1946; Pettibone 1963).

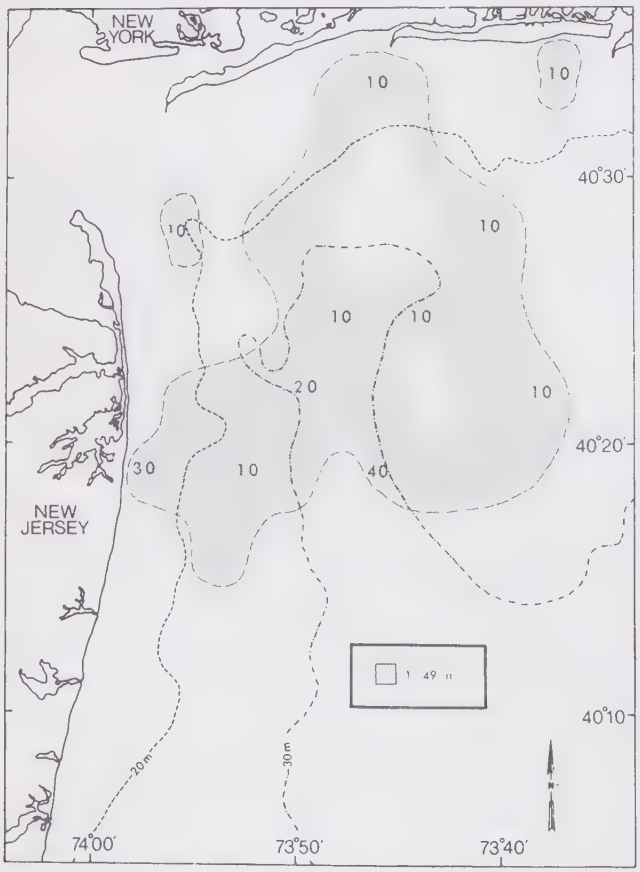

Figure 25.—Distribution and abundance of *Phyllodoce arenae* in the New York Bight apex.

ADDITIONAL INFORMATION: McLusky and Phillips (1975) studied the effects of copper on *P. maculata*. They found the threshold of toxicity of copper in seawater to this polychaete to be approximately 0.08 ppm. In a 1.00 ppm solution, worms accumulated 437.5 ppm copper within 2 d, after which death occurred. Higher accumulations, reaching 567.8 ppm, were found in worms which had been exposed to 0.06 ppm concentrations for 3 wk with no obvious side effects. This suggests that it is not the amount of copper contained in tissues which results in death, but some other factor such as rate of uptake. At lower rates of uptake, the animals may be able to cope by depositing the copper in the tissues or possibly by excreting it through the nephridial system. In a 0.08 ppm solution (the lethal concentration), the rate of uptake corresponds to an increase of about 25 ppm of copper per day, which is probably the critical rate of uptake.

Eteone longa (Fabricius, 1780)

DESCRIPTION: A slender-bodied burrowing form; length to 160 mm, width to 5 mm, segments to 200 (Pettibone 1963).

DISTRIBUTION: Widely distributed in the Arctic, also Iceland, Norway to English Channel, Hudson Bay to off North Carolina, Chukchi Sea to Mexico, north Japan Sea, China (Pettibone 1963; Reish 1965).

HABITAT: Found at low water in mud flats, muddy sand, sand, gravel, under stones, eelgrass. Also found in depths to 1,668 m in sandy mud, sand and shells, and in various combinations of soft mud, sand, gravel, pebbles, rocks, shells, and worm tubes (Pettibone 1963). In the New York Bight apex, *Eteone longa* was found in all sediment types in depths $\geq$14m, but was found in highest concentrations in high organic, silty-fine sand areas (Fig. 26; Table 1). Seasonal distributions were almost identical.

FEEDING ECOLOGY: Because of their active nature and well-developed eyes, it has been assumed that all phyllodocids are carnivores. Khlebovich (1959, cited in Fauchald and Jumars 1979) reported that *E. longa* feeds exclusively on the spionid polychaete, *Spio filicornis*; Michaelis (1971) found the same species to feed exclusively on another spionid polychaete, *Scolelepis squamata*, however, Retière (1967) found *E. longa* to be less selective, feeding on a variety of small metazoans.

Wigley (1956) stated that phyllodocids, in general, are among the most important foods of small (14–30 cm) Georges Bank haddock.

REPRODUCTION AND GROWTH: Pettibone (1963) reported that some specimens of *E. longa* were filled with yolky eggs during April 1954 in Rye Harbor and Hampton Harbor, N.H. According to Thorson (1946), the eggs are spawned in irregular, slimy masses and the larvae have a relatively short planktonic existence. In the Danish Isefjord, Rasmussen (1956, 1973) observed adults of *E. longa* swimming actively near the surface of the water in April and May, where eggs of 110 μm diameter were spawned. Planktonic larvae were found from late April to late May. The species is also known to reproduce at this time of year in England (Meek and Star-

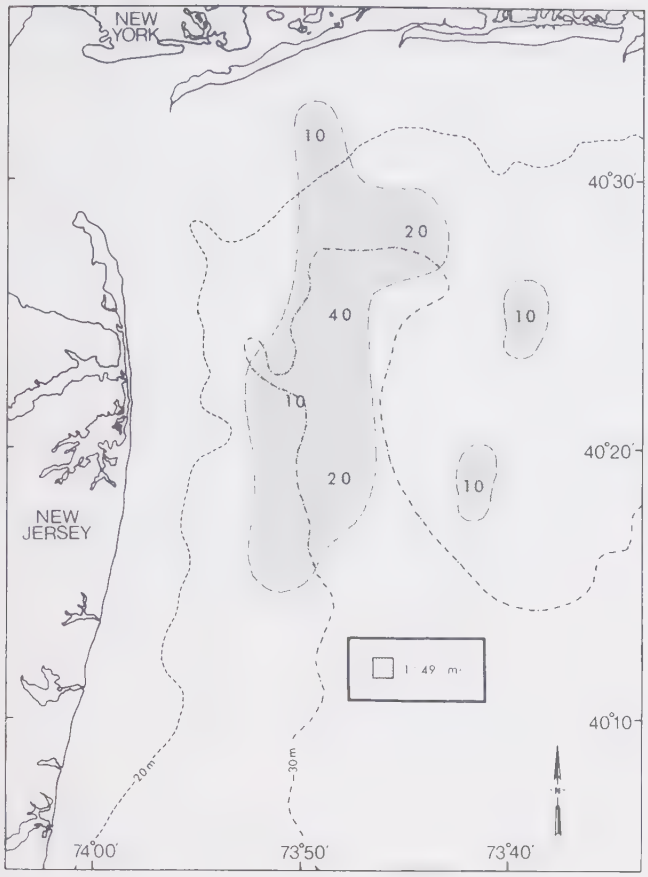

Figure 26.—Distribution and abundance of *Eteone longa* in the New York Bight apex.

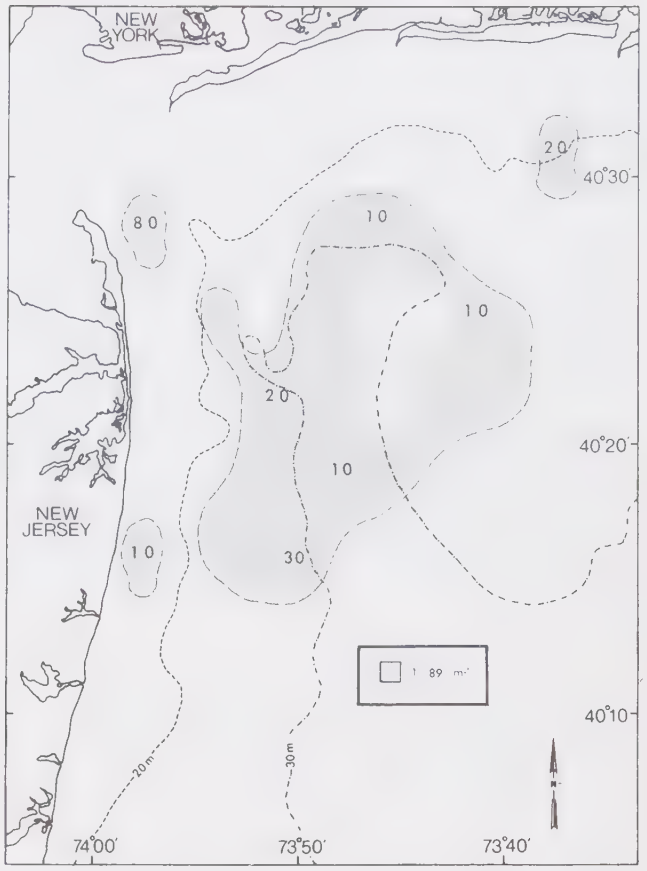

Figure 27.—Distribution and abundance of *Harmothoe extenuata* in the New York Bight apex.

row 1924). Rasmussen (1956, 1973) reported observing large numbers of young *E. longa* swimming in a warmer (12°C) backwater of a creek in East Jutland (Denmark), while mature adults in an adjacent colder portion (10°C) remained in the mud, indicating a possible correlation between temperature and spawning.

On the basis of living material, Rasmussen (1973) reported that *E. longa* is mature at a length of 20 mm (males) or 30 mm (females) in the Isefjord.

Harmothoe (*Lagisca*) *extenuata* (Grube, 1840)

DESCRIPTION: A crawling form, dorsal surface covered with elytra (scales). Body depressed, length to 74 mm, width including setae to 20 mm, segments 37–47.

DISTRIBUTION: Widely distributed in the Arctic. Also Iceland, Faroes, Norway to Mediterranean and Adriatic, Hudson Bay to Chesapeake Bay, North Carolina, Bering Sea to southern California, north Japan Sea, South Africa (Pettibone 1963; Gardiner 1975).

HABITAT: *Harmothoe extenuata* appears to have great powers of dispersal and adaptation, occurring from the intertidal to 1,830 m; euryhaline. It is often associated with two other common northern polynoids, *Lepidonotus squamata* and *Harmothoe imbricata* (often confused with *H. extenuata*). Intertidally, it is found under rocks, in tide pools with algae, sponges, etc.; on fronds of kelp; on pilings among mussels, tunicates, sponges, hydroids, etc.; abundant in beds of *Mytilus edulis*. *Harmothoe extenuata* is dredged on all types of bottom (Pettibone 1963). Our New York Bight apex data agree with these observations in that *H. extenuata* occurred, usually in small numbers, in all sediment types ranging from coarse sand to silt, with high to low organic levels (Fig. 27; Table 1).

FEEDING ECOLOGY: *H. extenuata* possesses a large proboscis, armed distally with two pairs of amber-colored interlocking jaws. They are slow-moving predators and, despite their strong jaws, feed on small prey (Pettibone 1963; Day 1967).

REPRODUCTION AND GROWTH: Reproductive strategies of *Harmothoe* spp. are variable.

In New Hampshire, female *H. extenuata* with coral-pink eggs inside the body were found in April 1954; other females were observed with eggs extruded and carried between the parapodia and on the ventral surface (Pettibone 1963).

Curtis (1977) observed that gametogenesis of *H. imbricata* (a closely related species) occurred in Greenland throughout autumn and winter with spawning activity confined to spring (March–May). Ripe, large eggs (150–180 μm) were richly supplied with yolk granules at spawning time. Maturity was reached at a length of 9–10 mm, with animals attaining a mean size of 6, 12, and 18 mm after their first, second, and third years of life, respectively; most individuals underwent reproductive development during their second year.

A population of *H. imbricata* at Arcachon, France, is described as having a completely planktonic larval development (Cazaux 1968), and Blake (1975) has also observed planktonic larvae on the California coast, where the species broods eggs of 120–123 μm

diameter, releasing them into seawater after the trochophore larvae have developed.

The size of mature oocytes in the study by Curtis (1977) in Greenland was similar to that found for *H. imbricata* in the Isefjord, Denmark, where they measured 150 μm (Rasmussen 1956). In the Isefjord, the species spawns in winter and produces typical trochophore larvae with a pelagic phase after intial brooding under the female elytra. However, egg size for *H. imbricata* is variable and Rasmussen cited other observations ranging from 50 to 76 μm. It is postulated that such small ova probably give rise directly to pelagic planktotrophic larvae without any early protection of the embryos.

Daly (1972, 1974) stated that *H. imbricata* is capable of completing its life cycle in a single year in British waters, where all survivors of a new year class apparently spawned at the end of their first year. The smallest specimens in the population at the time had reached a size of 9 mm, which closely coincides with the minimum size reported for the Greenland population (Curtis 1977). Each female underwent two successive spawnings, about 1 mo apart, releasing large oocytes (140–160 μm) to be brooded beneath the elytra.

***Sthenelais limicola* (Ehlers, 1864)**

DESCRIPTION: A burrowing form, with dorsal surface covered with translucent elytra (scales). Length to 100 mm, width including setae to 4 mm, segments to 200 or more (Pettibone 1963).

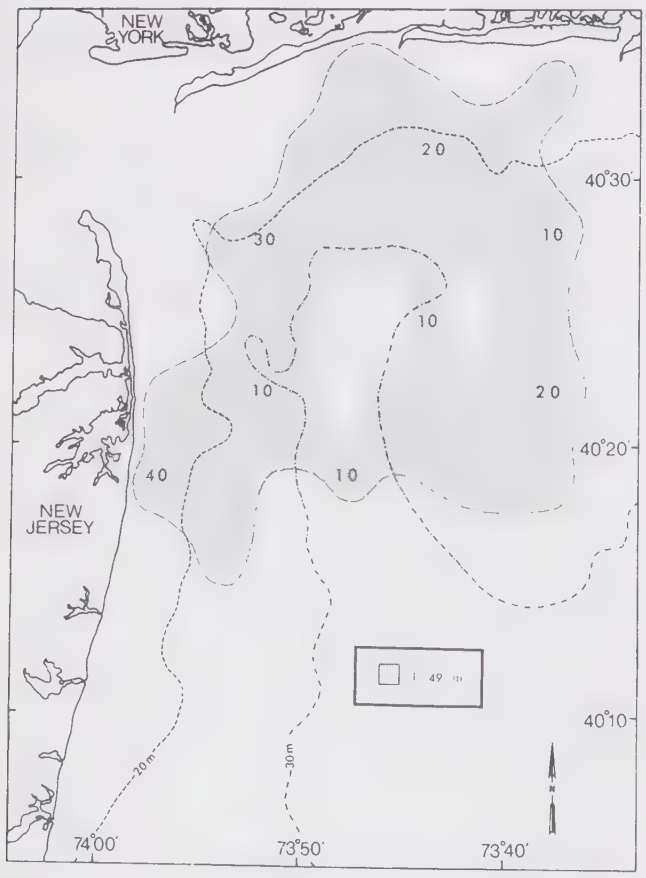

Figure 28.—Distribution and abundance of *Sthenelais limicola* in the New York Bight apex.

DISTRIBUTION: Gulf of St. Lawrence to North Carolina, Norway to Mediterranean, Adriatic, South and West Africa (Pettibone 1963).

HABITAT: Collected on sandy or muddy bottoms from the intertidal to 770 m (Pettibone 1963; Gardiner 1975). Kinner (1978) found *Sthenelais limicola* to be one of the dominant species in sand on the inner and mid-shelf from Georges Bank to Cape Hatteras. In the New York Bight apex, *S. limicola* was collected in all sediment types, usually in low numbers. It was most abundant in medium to fine, low organic sands (Fig. 28; Table 1).

FEEDING ECOLOGY: Members of this family (Sigalionidae) are, in general, burrowing predators (Day 1967). They are eaten by cod, flounder (McIntosh 1900), and haddock (Wigley 1956).

REPRODUCTION AND GROWTH: No information specific to the genus *Sthenelais* is available. Brooding among the Sigalionidae has not been reported as it has been for other scale worms of the family Polynoidae (Schroeder and Hermans 1975).

***Glycera dibranchiata* Ehlers, 1868**

DESCRIPTION: Commonly known as the "bloodworm," a commercially valuable bait worm. Active burrowers; length to 510 mm (Klawe and Dickie 1957).

DISTRIBUTION: Gulf of St. Lawrence to West Indies, Gulf of Mexico, central California to the Pacific coast of Mexico (Pettibone 1963; Hartman 1969; Gardiner 1975).

HABITAT: Intertidal to 400 m. Found at low water and collected in deeper water on bottoms of sand, mud, mud mixed with gravel, rocks, and particularly, mud rich in detritus. Found on more exposed beaches than *Glycera americana*, especially where currents flow swiftly; found in brackish waters and tidal estuaries (Pettibone 1963; Gardiner 1975). From Cape Cod to Cape Hatteras, Kinner (1978) found *Glycera dibranchiata* to be a dominant mid-shelf sand species. Kinner and Maurer (1978) regularly collected *G. dibranchiata* in Delaware Bay, with increasing numbers associated with sediments containing increasing amounts of silt-clay; Pearce, Caracciolo, Halsey, and Rogers (1977a) also found it to be abundant in New York-New Jersey outer continental shelf samples.

In the New York Bight apex, *G. dibranchiata* was found in depths ranging from 9.6 to 33.1 m. It was present in all grades of sand (none was found in silt), but was most abundant in fine sand. *Glycera dibranchiata* was absent or occurred in low numbers (10/m^2) in sediments having the highest organic content; it was most abundant in low organic sediments (Fig. 29; Table 1).

FEEDING ECOLOGY: *Glycera* spp. possess a strong, muscular, clavate proboscis, armed distally with four equally spaced large jaws. The proboscis serves glycerids as an organ of special sense, with a remarkably well-developed nervous system (Gravier 1898). Both Day (1967) and Fauchald (1977) agreed that glycerids appear to be mainly carnivorous, for very little sand is ever found in the gut; however, Sanders et al. (1962) believed glycerids to be omnivores. Klawe and Dickie (1957) classified them as detritus feeders and Adams and Angelovic (1970), in a feeding experiment using a radioactive tracer, carbon-14, also found detritus to be an important food source. Studies on *Glycera alba* showed them to be predaceous (Ockelman and Vahl 1970), possesing both proteolytic and

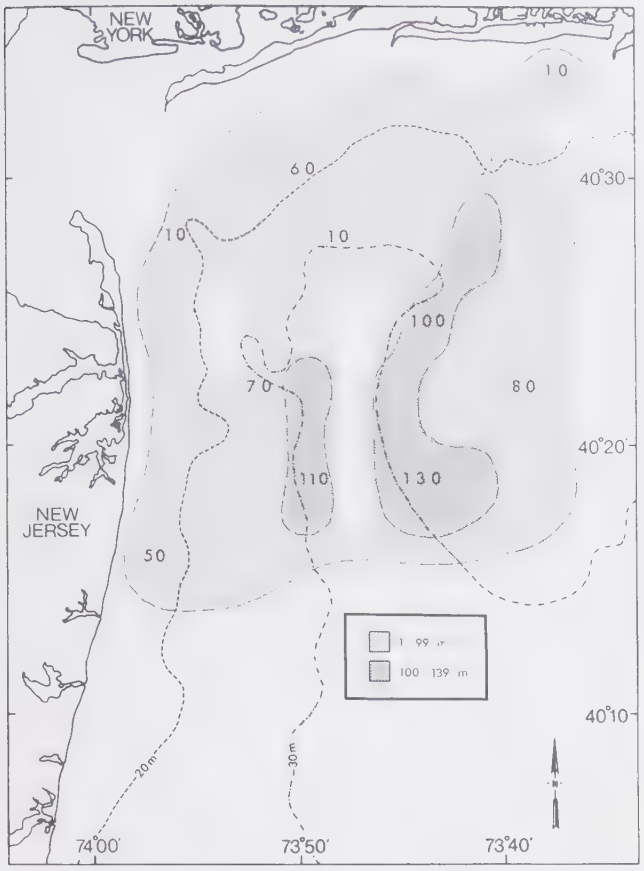

Figure 29.—Distribution and abundance of *Glycera dibranchiata* in the New York Bight apex.

lipolytic enzymes (Vahl 1976). On the basis of morphology, it may be postulated that glycerids are primarily carnivorous, but are capable of using other feeding modes under certain environmental conditions.

Spawning bloodworms are preyed on by herring gulls, *Larus argentatus*, and striped bass, *Morone saxatilis*, while spent epitokes are consumed by shrimp (*Crangon septemspinosa*) which, in turn, are eaten by striped bass (Creaser 1973). *Glycera dibranchiata* has also been found in the stomachs of haddock off Georges Bank (Wigley 1956).

REPRODUCTION AND GROWTH: The reproductive patterns of *G. dibranchiata* have been studied by several investigators. Klawe and Dickie (1957) made observations on a population of *G. dibranchiata* from Goose Bay at Wedgeport, Nova Scotia. They found that eggs and sperm began developing in late summer and were sexually mature by early April (fully developed eggs measured between 180 and 190 μm in diameter). The peak of spawning took place in mid-May; after spawning, remains of spent worms were found on the flats, appearing as "ghost worms," consisting of outer skin and atrophied digestive tract with everted proboscis. This indicated that life terminates after spawning (the spawning process itself was not observed). Eggs developed into planktonic larvae which, after a short time, transformed into bottom dwellers.

From an analysis of distribution of size classes in the population, Klawe and Dickie (1957) determined that most of the intertidal population lives for 3 yr and that they spawn before reaching the fourth year; a small fraction spawn when 4 or 5 yr old. Growth is most rapid during the second and third years, decreasing sharply thereafter.

In contrast, the study by Simpson (1962) showed *G. dibranchiata* to breed twice a year in Solomons, Md., during fall and during late spring or early summer as well. She observed swarming taking place over a moderately large area in shallow water during late afternoon on 5–8 November 1960. Her data suggested that the onset of swarming may be coordinated with tidal conditions. The pelagic larvae that were produced were nearly or fully indifferent to light in their early phases. Her other findings were in general agreement with those of Klawe and Dickie (1957).

Creaser (1973) studied a population of *G. dibranchiata* in Wiscasset, Maine. He found them to spawn annually in June, usually at an age of 3 or 4 yr. A bottom temperature in excess of 13°C seemed necessary for spawning to occur. Generally, between 2 h before and 1 h after high water in the afternoon, males emitted streams of sperm while swimming at the surface, while females swam rapidly at the surface and suddenly ruptured, liberating all eggs at once. Eggs usually measured 151–160 μm in diameter. Klawe and Dickie (1957) have calculated that a bloodworm measuring 22–24 cm may contain 1.5–2.0 million eggs. A Wiscasset bloodworm of this length would be expected to contain 3.0–3.5 million eggs. The emission of gametes in the Maine study was not, however, confined to surface waters. Creaser (1973) also observed a male in 3 m of water swimming in a vertical position just above the bottom emitting sperm.

All observations agree with the belief of Klawe and Dickie (1957) that all bloodworms die after spawning, with 5 yr the maximum life span. The size range of sexually mature bloodworms in Maine was between 18 and 51 cm (Creaser 1973); in Nova Scotia, 13–36 cm (Klawe and Dickie 1957); in Maryland, 7–26 cm (Simpson 1962). These geographical differences in size of bloodworms may be attributed to the effects of temperature on growth and maturity or possibly to differences in races of bloodworms. An interesting observation made by Klawe and Dickie (1957) was that *G. dibranchiata* does not grow in summer months. This finding is in direct contradiction to almost every other temperate or boreal invertebrate studied.

ADDITIONAL INFORMATION: *G. dibranchiata* is harvested extensively from the mud flats of Maine and other Gulf of Maine areas. There, it supports a multimillion dollar bait worm industry. In the New York Bight, it is not commercially harvested, but is collected by recreational fishermen.

Goniadella gracilis (Verrill, 1873)

DESCRIPTION: Active worms making temporary burrows in sand (Dales 1963). Length to 50 mm, width to 1 mm, segments to 100 or more (Pettibone 1963).

DISTRIBUTION: Massachusetts to Virginia; Irish Sea, Liverpool Bay, South Africa (Walker 1972; Day 1973).

HABITAT: Intertidal to 450 m (Day 1973). Found burrowing in fine sand at low water; collected on bottoms of fine gravel, fine to coarse sand and soft mud (Pettibone 1963; Walker 1972). *Goniadella gracilis* was one of the dominant species on the mid-continental shelf in the Delaware Bay region, associated with poorly sorted, coarse sediments (>1 mm) (Kinner and Maurer 1978), and was among the 15 most abundant taxa on Georges Bank in winter (Maurer and Leathem 1980). It was also abundant in some

areas on the New York-New Jersey outer continental shelf (Pearce, Caracciolo, Halsey, and Rogers 1977a). In the New York Bight apex, *G. gracilis* occurred in depths ranging from 9.6 to 34.0 m. It was most abundant in coarse to medium sand with an organic content between 1.0 and 3.3%. It was not present in fine sediments with extremely high organic contents (Fig. 30; Table 1).

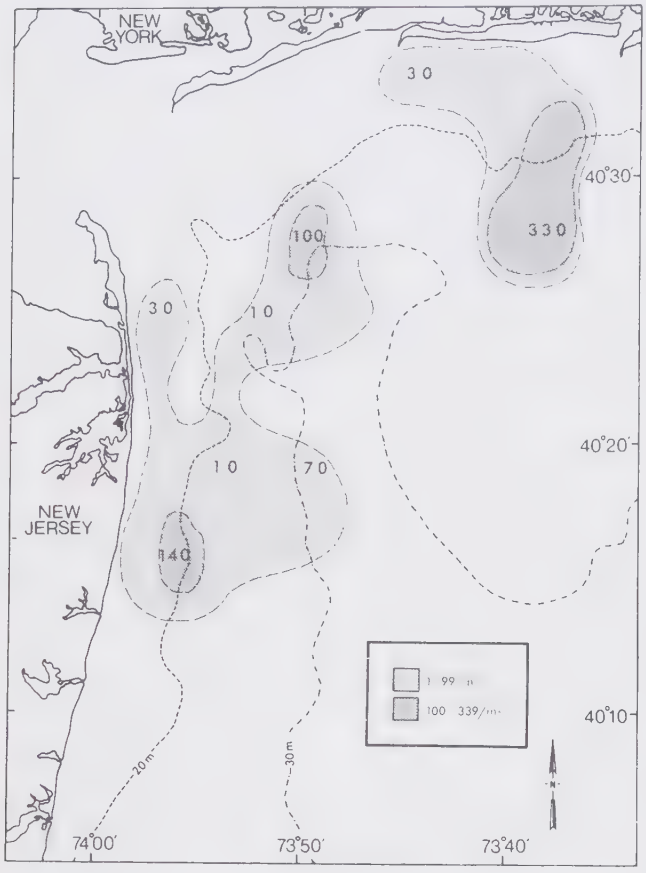

Figure 30.—Distribution and abundance of *Goniadella gracilis* in the New York Bight apex.

FEEDING ECOLOGY: The Goniadidae have well-developed jaws and probably most species are predators, or at least carnivores, for very little sand is ever found in the gut (Pettibone 1963; Day 1967).

Wigley (1956) reported that *G. gracilis* has been found in the stomachs of haddock off Georges Bank.

REPRODUCTION AND GROWTH: Pettibone (1963) reported that, when sexually mature, the Goniadidae may become modified into an epitokous swimming form. In the posterior region, where the sex products are formed, parapodial lobes become more elongate.

ADDITIONAL INFORMATION: During the 1976 anoxic event off the coast of New Jersey, *G. gracilis* was abundant at heavily impacted stations, implying a high tolerance of oxygen depletion (Steimle and Radosh 1979). This was unexpected because in the New York Bight apex samples, *G. gracilis* was rare in high organic areas; this species is also known to be characteristic of ridge environments (Boesch et al. 1977; Radosh et al. 1978[8]) in which anoxic episodes may be relatively rare.

Nephtys bucera Ehlers, 1868

DESCRIPTION: An active burrowing species, length to 300 mm, width to 20 mm, segments to 140 (Pettibone 1963).

DISTRIBUTION: Gulf of St. Lawrence to North Carolina, Gulf of Mexico (Pettibone 1963; Gardiner 1975).

HABITAT: Intertidal to 180 m; found at low water in sand bars, shifting sand, muddy sand, and collected from bottoms of sand and stones (Pettibone 1963; Gardiner 1975). *Nephtys bucera* was collected on the New York-New Jersey outer continental shelf (Pearce, Caracciolo, Halsey, and Rogers 1977a) as well as in the New York Bight apex, where it was found in all sediment types, particularly medium to fine grained low organic sand. *Nephtys bucera* was rarely found in high or medium organic content sediments (Fig. 31; Table 1).

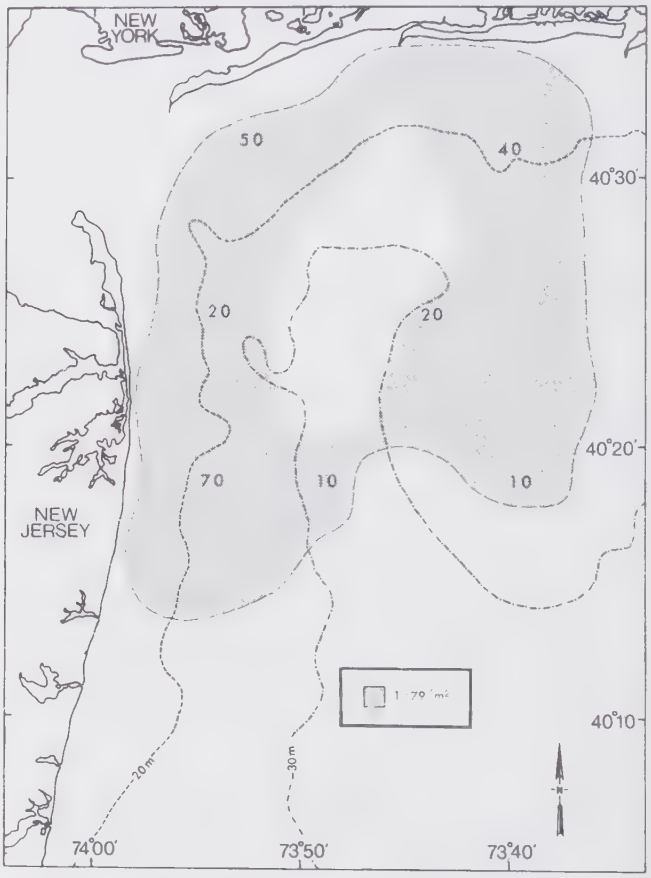

Figure 31.—Distribution and abundance of *Nephtys bucera* in the New York Bight apex.

FEEDING ECOLOGY: *N. bucera* is probably a surface deposit feeder and/or carnivore (see following account of *Nephtys incisa*).

REPRODUCTION AND GROWTH: No specific information was available for *N. bucera*, however, it is probable that they produce planktotrophic larvae (see *N. incisa*).

[8]Radosh, D., A. Frame, T. Wilhelm, and R. Reid. 1978. Benthic survey of the Baltimore Canyon Trough, May 1974. Northeast Fisheries Center Sandy Hook Laboratory, Informal Rep. SHL 78-8, 133 p.

Nephtys incisa **Malmgren, 1865**

DESCRIPTION: A mobile, burrowing, large species, reaching a maximum length of 150 mm, width to 15 mm, segments to 75 (Pettibone 1963).

DISTRIBUTION: Greenland, Davis Strait, Ireland, Norway, Sweden, North Sea, Baltic to Portugal, Mediterranean, Gulf of St. Lawrence to Virginia, Chesapeake Bay, North Carolina (Pettibone 1963; Gardiner 1975).

HABITAT: Intertidal to 1,745 m; found on bottoms of soft or sticky mud, muddy sand, very fine or coarse sand, mud which contains gravel, shells, worm or amphipod tubes, or decaying debris (Pettibone 1963; Day 1967). Pettibone (1963) reported *Nephtys incisa* to be "the most common and abundant species on muddy bottoms along the New England coast, in bays and sounds as well as off the open coast." In these situations, it is usually associated with the bivalves *Nucula proxima* and *Yoldia limatula*, members of a distinct deposit-feeding soft bottom community (Sanders 1958, 1960). From Cape Cod to Cape Hatteras, Kinner (1978) found *N. incisa* to be a dominant on the mid-outer shelf in silt-clay. Pearce (1972) found *N. incisa* in greater abundance around sludge deposits in the New York Bight apex than in relatively unpolluted habitats.

In the present New York Bight apex study, *N. incisa* was present in all sediment types but was clearly most abundant in fine sand or silty areas having the highest percentages of sediment organic material (Fig. 32; Table 1).

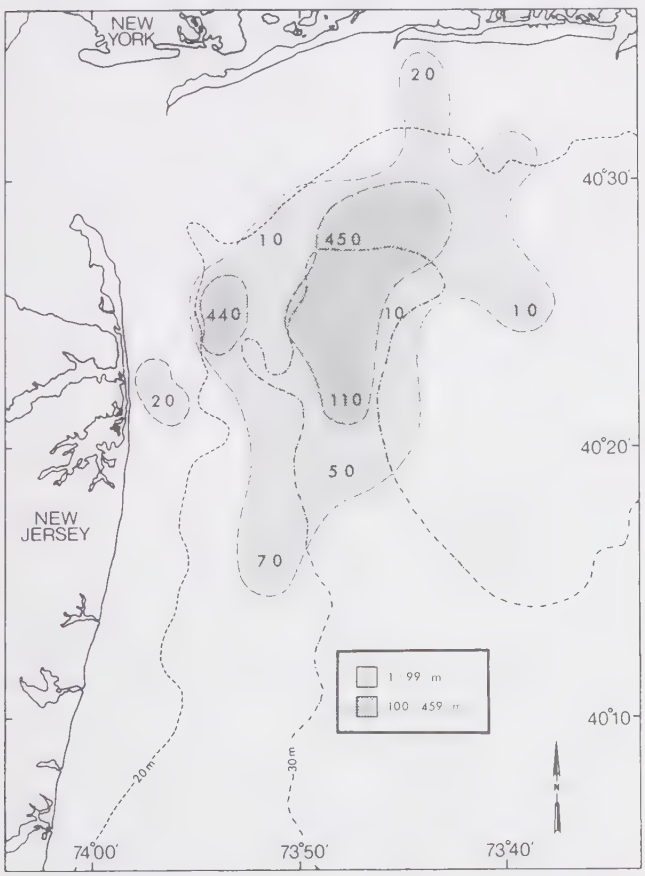

Figure 32.—Distribution and abundance of *Nephtys incisa* in the New York Bight apex.

FEEDING ECOLOGY: Until recently, it was thought that all nephtyids were strict carnivores, probably because they possess large jaws, but Sanders (1956, 1960) found *N. incisa* in Long Island Sound and in Buzzards Bay, Mass., to be nonselective deposit feeders. Sanders, however, did not deny that *N. incisa* was capable of acting as a carnivore under certain conditions. Conversely, Clark (1962) believed *N. incisa* is, at best, a facultative detritus feeder, primarily because its gut is almost always empty indicating a carnivorous diet and rapid digestion. Day (1967) believed them to be selective omnivores because they are found in such large numbers in certain areas.

Nephtys incisa is also important as a prey item. Wigley and Theroux (1965) found it to be a principal annelid, along with *Aphrodita hastata*, in the diet of haddock.

Tyler (1973) found Canadian specimens to have no seasonal trend in caloric value; the annual mean for *N. incisa* was 3,984 g cal/g dry weight.

REPRODUCTION AND GROWTH: *N. incisa* spawns yearround in Long Island Sound with peaks in early spring and late summer (Sanders 1956). Specimens of *N. incisa* with coral-pink eggs have been found in August in Massachusetts and young specimens of 28–32 segments have been found in August in Maine (Pettibone 1963). *Nephtys incisa* does not brood its young, but produces large numbers of planktotrophic larvae (10^3–10^6 per female) which undergo a long pelagic development. Time to maturity is unknown (Thorson 1946; Sanders 1956; Clark 1961, 1962).

Relative to more opportunistic species, *N. incisa* exhibits slow development, few reproductions per year, low recruitment, and low death rate. Because of these factors, because they do not brood developing young, and because they produce large numbers of planktotrophic larvae, they are classified as an "equilibrium" species, present early in colonization, but remaining at low and constant abundance (McCall 1977).

ADDITIONAL INFORMATION: There is some evidence, including that provided in this study, that *Nephtys* spp. are highly tolerant of some environmental stresses (Jones 1955; Weber 1971). They are also physiologically equipped for infrequent feeding and long periods of starvation (Clark 1964). Mobility and size could also aid these polychaetes in both escape from predators and migration to more favorable microenvironments.

Nephtys picta **Ehlers, 1868**

DESCRIPTION: A mobile species, length to 60 mm, width to 4 mm, segments to 100 (Pettibone 1963).

DISTRIBUTION: New England to Florida, Gulf of Mexico (Gardiner 1975).

HABITAT: Intertidal to 40 m (Pettibone 1963); 8–141 m, usually <50 m (Kinner 1978). Found at low water in muddy sand, sandy rubble, gravelly sand. Collected on bottoms of sand and muddy sand, with shells and sea weeds (Pettibone 1963). In the New York Bight apex, *Nephtys picta* was found in all grades of sand, most commonly in medium to fine sand. It was not found in high organic sediments and was rare in medium organic sediments (Fig. 33; Table 1). Kinner (1978) found *N. picta* to be a dominant species in sand on the inner shelf from Georges Bank to Cape Hatteras, while Kinner and Maurer (1978) reported increasing numbers of *N. picta* associated with sediments containing increasing amounts of silt-clay in Delaware Bay.

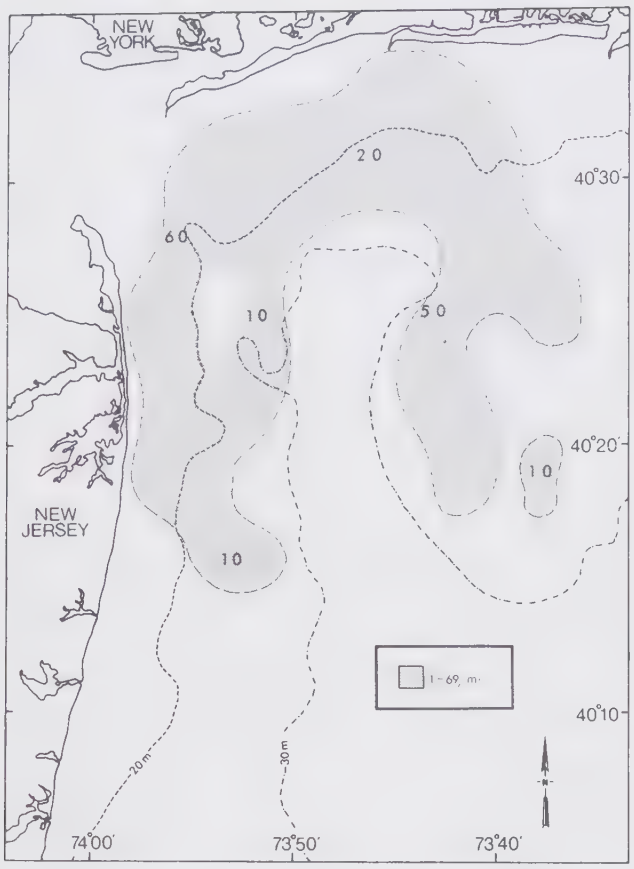

Figure 33.—Distribution and abundance of *Nephtys picta* in the New York Bight apex.

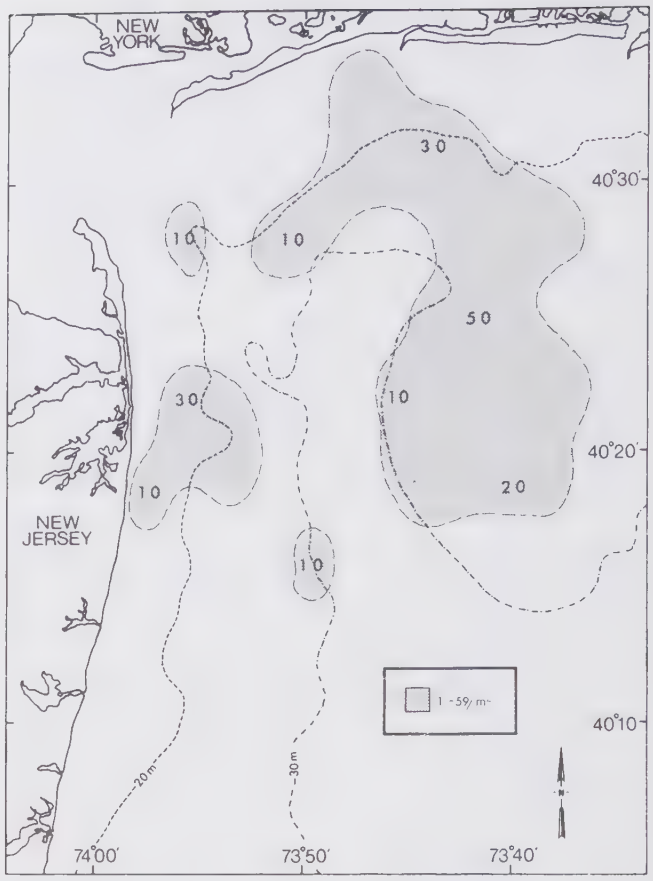

Figure 34.—Distribution and abundance of *Nephtys* (*Aglaophamus*) *circinata* in the New York Bight apex.

FEEDING ECOLOGY: *N. picta* is probably a surface deposit feeder and/or carnivore (see *Nephtys incisa*).

REPRODUCTION AND GROWTH: No information specific for *N. picta* was available, however, planktotrophic larvae are probably produced (see *N. incisa* for details).

***Nephtys* (*Aglaophamus*) *circinata* Verrill, 1874**

DESCRIPTION: A mobile species; length to 50 mm, width to 5 mm (Pettibone 1963).

DISTRIBUTION: Gulf of St. Lawrence to North Carolina (Gardiner 1975).

HABITAT: Collected on bottoms of mud, sand with gravel, rocks, shells (Pettibone 1963); found from Cape Cod to Cape Hatteras in depths of 13–611 m (Kinner 1978). In Delaware Bay, *Nephtys circinata* was not significantly associated with any sediment parameters; it was found in a range of sediment types (Kinner and Maurer 1978). On Georges Bank, it was an abundant species negatively correlated with silt-clay (Maurer and Leathem 1980). Steimle and Radosh (1979) found it to be a ubiquitous species in sandy sediments off New Jersey. In the New York Bight apex, *N. circinata* was present in fine to coarse sandy sediments, most commonly in fine sands, but was absent from silty sediments and areas where sediment organic content exceeded 3.8% (Fig. 34; Table 1).

FEEDING ECOLOGY: *N. circinata* is probably a nonselective deposit feeder and/or carnivore (see *Nephtys incisa*).

REPRODUCTION AND GROWTH: Nothing is known of the reproductive patterns of *N. circinata* in this area. However, it is probable that it produces planktotrophic larvae (see *N. incisa*). Winter and summer distribution and abundance patterns were similar in the New York Bight apex.

Order Capitellida

***Capitella capitata* (Fabricius, 1780)**

DESCRIPTION: Motile burrowers which form mucus-lined galleries; body slender, generally 30–50 mm long, dark red when alive (Day 1967; Gosner 1971). Grassle and Grassle (1976) believed that *Capitella capitata* is not a single species but a complex of at least six sibling species, each with a different life history. Therefore, information here reported may apply to a species complex rather than to a single species.

DISTRIBUTION: A cosmopolitan species, occurring in cold, temperate, and warm waters throughout the world (Warren 1976).

HABITAT: *C. capitata* is often used as an indicator of pollution and also of unpredictable environments all over the world (Muus 1967; S. Schultz 1969; Wolff 1973). The species becomes common

in areas following a period of oxygen depletion (Leppäkoski 1969; Steimle and Radosh 1979), in sludge dumps (Halcrow et al. 1973; Pearce, Caracciolo, Halsey, and Rogers 1977b; Pearce, Rogers, Caracciolo, and Halsey 1977), and in sediments contaminated by oil (Reish 1965; Sanders et al. 1972). Henriksson (1969) demonstrated a linear correlation between counts of bacteria indicative of pollution and the abundance of *C. capitata* in the Oresund, Denmark.

Capitella capitata is found in numbers as high as 60,000/m² at depths up to 637 m off California in areas where the normally diverse deep-sea fauna is absent or uncommon (Hartman 1961). Similarly, it has been noted by several investigators (Leppäkoski 1969; Barnard 1970; Sanders et al. 1972) working in other areas, that for *C. capitata* to achieve large population sizes, other species must be absent or present in low numbers; this suggests that *C. capitata* is a poor competitor. Wolff (1973) showed that *C. capitata* was not very responsive to sediment differences and Reish (1971) even found them settling on blocks of wood in Los Angeles Harbor. Warren's (1977) study of environmental variables likely to affect the distribution of *C. capitata* suggested that a high organic content is most important, with particle size of sediments indirectly influencing the distribution of the species through its relationship with organic content, *C. capitata* being most common in fine sands. This appears to be true in the New York Bight apex where *C. capitata* was highly concentrated in high organic fine sand (up to 5,000/m²) near the center of the sewage sludge disposal site. It occurred in other areas of the apex, but at much lower concentrations (10–40/m²). Since fine sandy sediments with similar depth regimes and lower organic contents are common in the apex, it appears that the very high organic content and/or the lack of competitors in the sludge disposal area was the prerequisite for the dense settlement of the species (Fig. 35; Table 1).

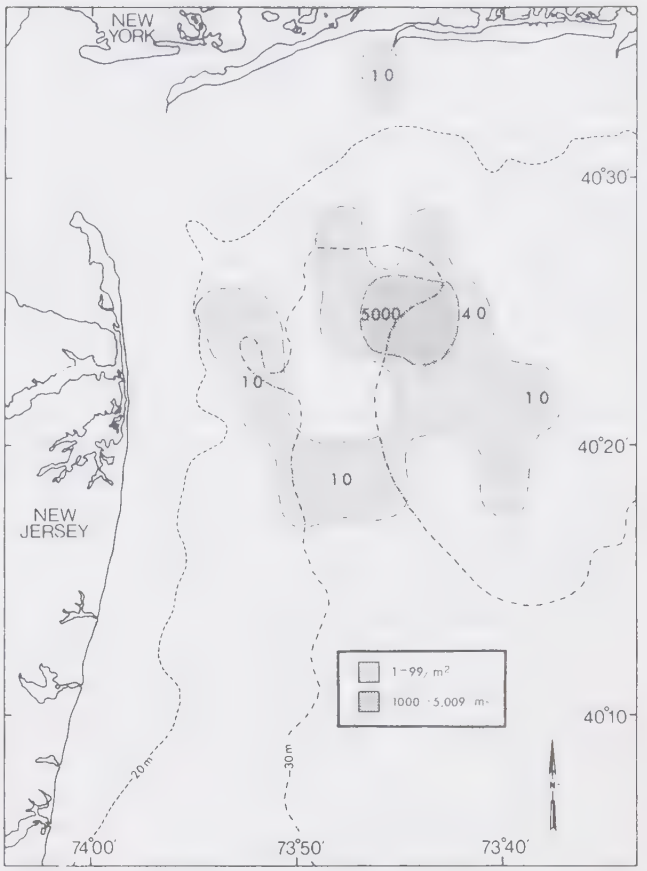

Figure 35.—Distribution and abundance of *Capitella capitata* in the New York Bight apex.

FEEDING ECOLOGY: Capitellids use their eversible proboscis to burrow, and they are generally thought to be nonselective deposit feeders. Since *C. capitata* does not possess the enzymes to digest plant material, Warren (1977) concluded that microorganisms form the bulk of its food. Stephens (1975) reported minimal bacterial consumption in *C. capitata* and believes nutrition is achieved by direct absorption of microorganism-associated dissolved amino acids across the body wall, however, the net energy gain is not clear. Tenore and Hanson (1980), in an experiment using different types of radioactively labelled detritus, found that the faster the decomposition of the detritus, the greater the amount utilized in the growth of *C. capitata*.

REPRODUCTION AND GROWTH: In West Greenland, small oocytes of *C. capitata* were formed during most of the year but these attained spawning size only in the spring (March–April 1959; April 1960) (Curtis 1977). In England, estimates of total number of oocytes produced ranged from 10,000 in young females to 14,400 in older worms, most eggs released in a single spawning (Warren 1976). However, *C. capitata* is able to breed throughout the year as it has been observed to do in Buzzards Bay, Mass., (Driscoll 1972) and at Warren Point, England (Warren 1976). When food is always available, their asynchronous mode of reproduction allows them to exploit their resources to the fullest without placing too heavy a demand on food supply at any one time. Muus (1967) found egg number in Danish specimens to average 130, with adults producing one to several broods.

Warren (1976) found the yolky egg to require 10–14 d development in the maternal tube and a further 7 d before metamorphosis as a lecithotrophic, planktonic larva. According to Eisig (1914), these larvae are photopositive. Rasmussen (1956, 1973) found two separate modes of development in the Isefjord, Denmark, where larvae developed nonpelagically during winter within adult tubes, but in summer, eggs were protected within the brood for only 10–14 d before a free-swimming stage emerged. Reish (1965) described a single specimen from the Bering Straits which was incubating eggs within the maternal tube during July. In West Greenland, a number of specimens were found brooding eggs and early unsegmented larvae within their tubes (Curtis 1977). Rasmussen (1956), Muus (1967), and Grassle and Grassle (1974) all agreed that larval development may be completely benthic. By this alternative mode of reproduction, *C. capitata* can rapidly exploit local concentrations of organic matter.

Newly metamorphosed larvae have been observed in the Woods Hole, Mass., plankton in June (Simon and Brander 1967), in spring in the Isefjord (Rasmussen 1973), and in late summer and early fall in the Elbe Estuary, Germany (Giere 1968). In Wild Harbor, Mass., settlement of planktonic larvae has been observed in late winter and summer with greatest settlement from May to October. Larvae have been collected from the plankton essentially year-round in the Oslofjord, Norway (Schram 1968), at Banyuls sur Mer (Bhaud 1967), and in the Gulf of Marseilles, France (Casanova 1953). It is possible that planktonic larvae are produced only in dense populations or when food is scarce.

Adult size can vary from about 1 mm to a maximum of 100 mm; Curtis (1977) reported maturity to be reached at a length of about 10 mm in West Greenland. Grassle and Grassle (1974) reported that

time to maturity is fairly constant at about 30–40 d, thus emphasizing the importance of rapid maturation in opportunistic species, even where resources permit production of only a few eggs.

Sexes are normally separate and, according to Warren (1976), occur in approximately equal proportions. Males are readily distinguished by large copulatory setae on the eight and ninth setigers. In laboratory and field populations, Grassle and Grassle (1974) have found that some genetically distinct individuals change sex from male to female and may be self-fertilizing before the transition is complete. This is an obvious advantage where the pattern of dispersal and the distribution of suitable habitats results in only a few individuals reaching a particular unexploited habitat.

ADDITIONAL INFORMATION: The cosmopolitan distribution of *C. capitata* and its tolerance of wide ranges of temperature, salinity, oxygen content, and a variety of other conditions inimical to other organisms cannot fully be explained since laboratory studies do not show unusual ranges of tolerance to any of these environmental variables. For example, Reish (1970) compared *C. capitata* with three other species of polychaetes on the basis of their tolerance to different concentrations of nutrients, salinity, and oxygen. *Capitella capitata* was most sensitive to increased concentrations of silicates, second most sensitive to reduced oxygen conditions, but most tolerant of increased phosphates and reduced salinities. Henriksson (1969) found *C. capitata* to be less tolerant of low oxygen conditions than *Nereis diversicolor* or *Scoloplos armiger*. Mangum and Van Winkle (1973) demonstrated that *C. capitata* had no unusual regulatory ability in decreased oxygen concentrations although *C. capitata* could repay an oxygen debt whereas *Polydora ligni* could not. Laboratory studies do not reveal any unusual tolerance to detergents or to heavy metals (Kaim-Malka 1970; Bellan et al. 1972; Reish et al. 1974). The Wild Harbor (Massachusetts) studies (Sanders et al. 1972) indicate that *C. capitata* is more sensitive to high concentrations of oil than *Nereis succinea* and Rossi et al. (1976) found *C. capitata* to be more sensitive to three of four test oils used than *Nereis arenaceodonta*.

Results of these studies would seem to indicate that a synergistic effect of several factors, e.g., the concentrations of organic matter, dissolved oxygen, etc., may be responsible for determining population levels of *C. capitata* in a given situation. Another explanation might be that if *C. capitata* is indeed a complex of six sibling species (Grassle and Grassle 1976), and if all or a few of these species were present in a certain area, at a certain time, the most "fit" or tolerant of existing conditions could be selected for.

Mediomastus ambiseta (Hartman, 1947)

DESCRIPTION: Small burrowing, motile worms; length to about 38 mm in our collections.

DISTRIBUTION: East coast of United States, southern California, and lower California (Hartman 1969; Hobson 1971).

HABITAT: Intertidal and shelf depths (Hobson 1971). *Mediomastus ambiseta* was collected in high numbers from coarse sand and a serpulid polychaete assemblage in Delaware Bay (Maurer, Watling, Leathem, and Kinner 1979; Haines and Maurer 1980). In the New York Bight apex, *M. ambiseta* reached very high concentrations in high organic silty sediments (up to 8,820/m^2 in summer). It was also abundant in medium to high organic content fine sands (up to 840/m^2 in summer), but occurred in lower numbers in coarse and medium sand and in lower organic areas (Fig. 36).

FEEDING ECOLOGY: All members of this family (Capitellidae) are deposit feeders (Day 1967; Gosner 1971).

REPRODUCTION AND GROWTH: Although no specific information is available on the reproduction and growth of *M. ambiseta* , following the West Falmouth (Massachusetts) oil spill, it exhibited some degree of opportunism (Sanders et al. 1972). Therefore, it may be characterized by rapid development, many reproductions per year, high recruitment, high death rate, and some form of brood protection (McCall 1977).

There were 5.9 times more *M. ambiseta* at the Bight apex stations during summer months than in winter (Fig. 36).

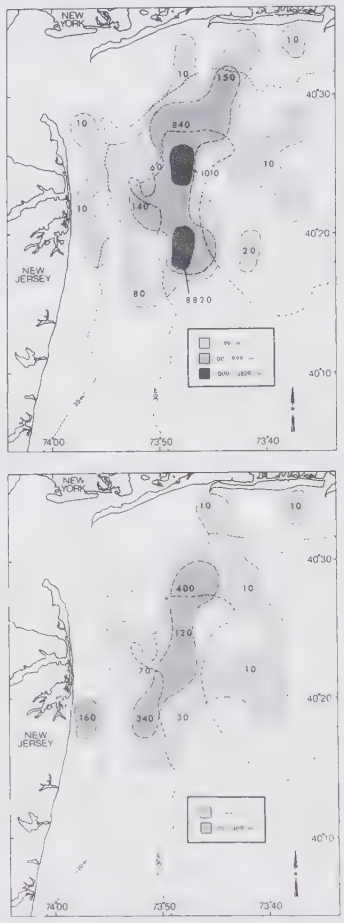

Figure 36.—Distribution and abundance of *Mediomastus ambiseta* in the New York Bight apex (top—summer, bottom—winter).

Travisia carnea Verrill, 1873

DESCRIPTION: A stout-bodied, grublike worm; length to 59 mm, width 8 mm, segments 25–29 (Pettibone 1954). (Only Alaskan specimens reach maximum size reported.)

DISTRIBUTION: Northeastern United States to Chesapeake Bay; Arctic Alaska (Verrill 1873; Pettibone 1954; Kinner and Maurer 1978).

HABITAT: Found at depths between 5.4 and 34.2 m. In the apex of the New York Bight, *Travisia carnea* occurred in low numbers,

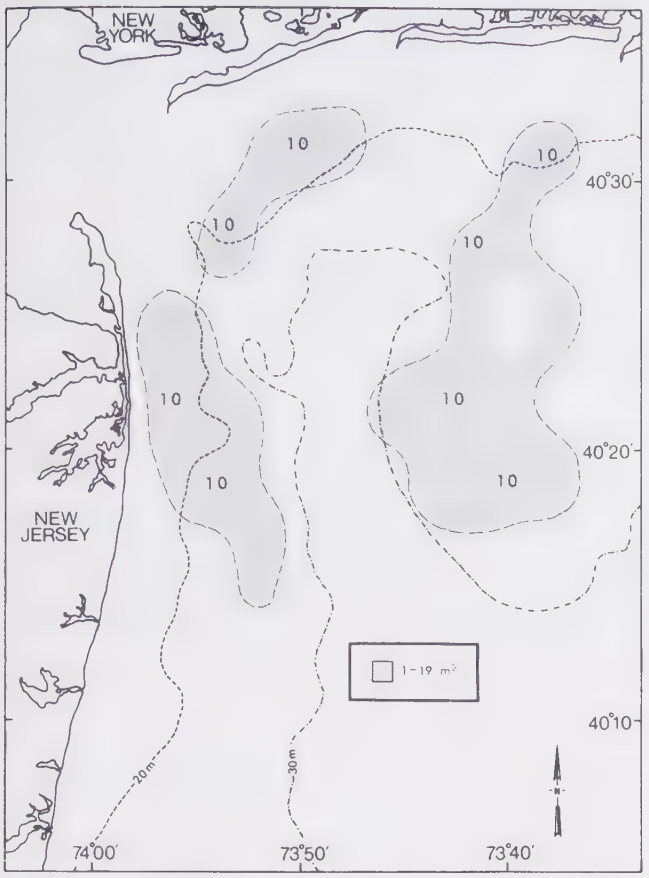

Figure 37.—Distribution and abundance of *Travisia carnea* in the New York Bight apex.

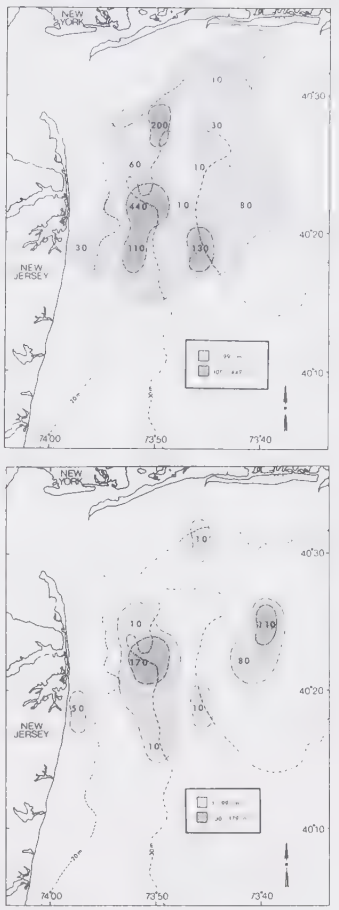

Figure 38.—Distribution and abundance of *Spio filicornis* in the New York Bight apex (top—summer, bottom—winter).

primarily in fine sand, and only in the lowest organic areas (<3%) (Fig. 37; Table 1).

FEEDING ECOLOGY: *T. carnea* is a motile deposit feeder which burrows head downward in the sediment. Its gut has often been observed to be full of sand grains ingested along with the organic matter in the substrate (Day 1967).

REPRODUCTION AND GROWTH: No information was available for this species.

Order Spionida

Spio filicornis (Muller, 1776)

DESCRIPTION: Usually tubicolous as are other spionids, but can leave tube (Remane 1933); length to 30 mm, 90 segments, usually smaller (Day 1967).

DISTRIBUTION: Worldwide (Hartman 1969).

HABITAT: *Spio filicornis* often forms dense colonies on sandbanks (Day 1967). In the New York Bight apex, we found *S. filicornis* in depths ranging from 9.6 to 45.6 m. It was usually associated with medium to fine sands with low to medium organic content (Fig. 38).

FEEDING ECOLOGY: *S. filicornis* is a tentaculate surface deposit feeder (Day 1967).

REPRODUCTION AND GROWTH: Although mating in *Spio* spp. has not been observed, on the basis of observations during culture experiments, Greve (1974) has hypothesized that *S. filicornis* is unusual in that it uses the indirect transfer of pelagic spermatophores to fertilize its eggs. Other marine organisms exhibiting a similar behavior are members of the Halacaridae (marine mites). The reproductive activities of *S. filicornis* have also been studied by Curtis (1977) in Godhavn, Greenland. He reported that spawning occurs during autumn or winter with the release of large (180–300 μm) eggs. Eggs were brooded within the female tubes until late spring, when they developed into larvae with three setigers bearing long swimming setae. As is the case with members of the genus *Polydora*, these larvae appeared to metamorphose within the parental tubes, some juveniles (1 mm, 10 setigers) being found in an adult tube collected in April 1959. The onset of maturity occurred at a length of about 10 mm (2–3 mg).

In the Gullmar Fjord, Sweden, Hannerz (1956) observed that *S. filicornis* laid its eggs in gelatinous masses within or on top of the substratum. Brood protection was lacking, and the pelagic larvae metamorphosed at the 15-setiger stage.

Simon (1967, 1968) found that *Spio setosa*, a close relative of *S. filicornis*, exhibited poecilogony, spawning once in the late spring resulting in benthic larvae, and again in the fall with pelagic larvae.

Planktotrophic pelagic larvae with from 4 to 22 setigers were collected between mid-October and mid-February in Great Harbor, Woods Hole, Mass. They metamorphosed generally at the 18–20 setiger stage. Following the spring spawning, development occurred entirely within the parent tube. Benthic larvae metamorphosed at the 15–17 segment stage, leaving the parent tube and burrowing into the surrounding substratum. In response to a lack of suitable substratum, most *S. setosa* metamorphosed anyway, forming tubes of mucus. However, some larvae did not metamorphose for periods of up to 2 mo, increasing in size and sometimes in number of segments. Larvae survived and metamorphosed in 50, 75, and 100% seawater.

In the New York Bight apex, during summer months, we found more widespread occurrence of *S. filicornis*, and higher numbers at several scattered locations (Fig. 38).

Prionospio steenstrupi Malmgren, 1867

[*Prionospio malmgreni* var. *dubia* Day, 1961]

DESCRIPTION: Length to 45 mm, 100 segments (Day 1967); tubicolous, but can leave tubes (Remane 1933).

DISTRIBUTION: North Atlantic from Norway to Greenland and New Brunswick to Florida; Alaska to southern California; Japan, South Africa (Day 1973).

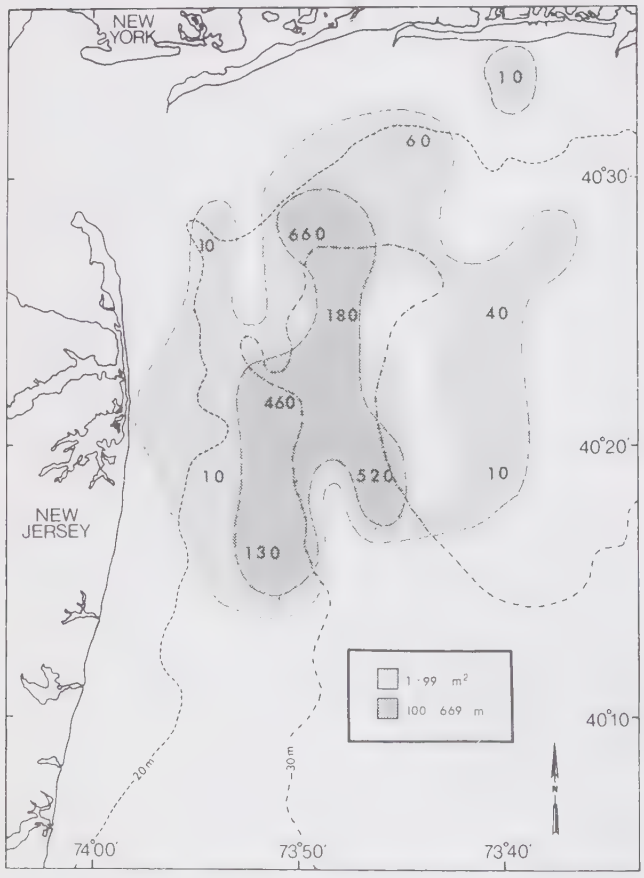

Figure 39.—Distribution and abundance of *Prionospio steenstrupi* in the New York Bight apex.

HABITAT: Intertidal to 1,745 m (Day 1973). Pearce (1972) found *Prionospio steenstrupi* to be more abundant in marginally polluted areas than in uncontaminated areas in the New York Bight apex. In the present samples, we also found *P. steenstrupi* to be most abundant in areas containing >3% organic material, occurring in highest concentrations in high organic (>5%) areas. They were abundant in all grades of sand and moderately abundant in silty sediments (Fig. 39; Table 1).

FEEDING ECOLOGY: The Spionidae are tentaculate, surface deposit feeders. They are probably nonselective since their guts contain many sand grains as well as detritus (Day 1967). Spionids are a major food item in the diet of haddock (Wigley and Theroux 1965).

REPRODUCTION AND GROWTH: Curtis (1977), in Greenland, found that the seasonal trend in oocyte size favored a winter or spring spawning period for *Prionospio malmgreni*. Hannerz (1956) reported that in the Gullmar Fjord, Sweden, mature ova measure 100 μm and development is planktotrophic with no brood protection. Day (1967) stated that various species of *Prionospio* must be very abundant, for their larvae are present in enormous numbers in neritic plankton samples.

Polydora ligni Webster, 1879

DESCRIPTION: Small, tubicolous worms; largest specimens measure 32 mm in length and have up to 80 segments (Blake 1971).

DISTRIBUTION: Cosmopolitan, in all oceans at all latitudes (Hartman 1969).

HABITAT: Intertidal to a few meters (Day 1973); *Polydora ligni* is a common inhabitant of estuaries in North America. In the New York Bight apex samples, *P. ligni* was found in depths to 46 m. They were present in all sediment types but were most common in medium to fine sand. Greatest abundance occurred in low organic areas; however, they were also represented in higher organic sediments (Fig. 40).

Hempel (1957) has studied the tubes of Spionidae and found that substrate materials used for building are not chosen at random, but are rather carefully selected. According to Kisseleva (1967), the determining factors in the selection of building materials are weight and quality of the substrate granules; for *Polydora ciliata* larvae, the critical factor is particle size, not composition.

FEEDING ECOLOGY: *P. ligni*, as all other spionids, is a surface deposit feeder (Day 1967). Breese and Phibbs (1972) found *P. ligni* in laboratory cultures feeding on larvae of the Manila clam, *Tapes semidecussata*, and the oyster *Crassostrea gigas*. One worm contained 20 larvae. The spionids entered the molluscan rearing tanks as larvae, and presumably fed on the algae *Monochrysis lutheri* and *Isochrysis galliana*, the food organisms used for culturing the molluscan larvae.

REPRODUCTION AND GROWTH: *P. ligni* lays its orange eggs (120 μm in diameter) in tough egg capsules. These may be protected inside the burrow, the female remaining with the developing larvae, and producing a current of water through the burrow, insuring continuous oxygenation. In Maine waters, these egg capsules have been collected from April to July with up to 132 eggs/capsule (Blake 1969); in the Woods Hole, Mass., area, the number

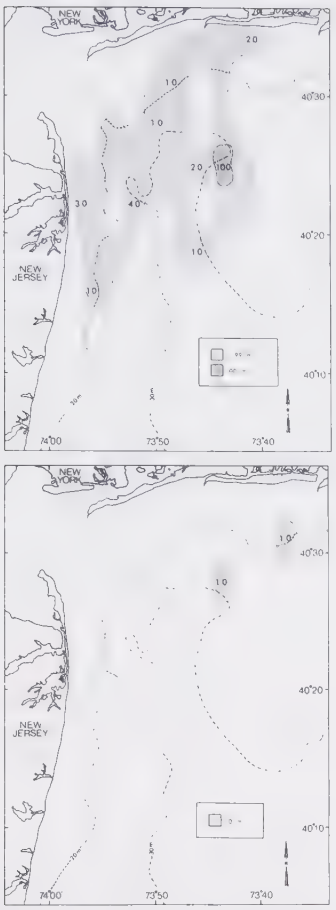

Figure 40.—Distribution and abundance of *Polydora ligni* in the New York Bight apex (top—summer, bottom—winter).

of egg capsules ranges from 4 to 29 with up to 216 eggs/capsule (Simon).[9] This agrees well with observations of up to 30 capsules with 25–225 eggs/capsule in the Isefjord, Denmark (Rasmussen 1973). Simon (1967) has observed developing larvae to sometimes use unfertilized eggs as a food source (adelphophagia). Two or more broods may be produced by each female in season (Blake 1969; Daro and Polk 1973). Larvae are not released into the plankton until they have reached the late 3-setiger stage (Hannerz 1956; Day 1967; Blake 1969). Large numbers of *P. ligni* larvae are present in the plankton of the Woods Hole area from March until September (Simon 1967). In the York River, Va., the occurrence of planktonic larvae of *P. ligni* was observed for a period of 12 wk in 1970. Larvae first appeared on 11 March and weekly samples generally showed a continuous increase in mean length. Maximum size was reached on 14 April, when inspection of test panels revealed an intitial settlement of metamorphosing larvae with a mean length of 1.25 mm. Larvae reared in the laboratory at 21°C required 19–28 d to develop fully, while larvae reared at 10°C required 60–69 d (Orth 1971). In another study, Breese and Phibbs (1972) observed *P. ligni* in laboratory culture to complete development to the adult stage and build tubes at salinities and temperatures ranging from 25 to 34‰ and 18° to 26°C.

In the Oslofjord, Norway, Schram (1968, 1970) found *P. ligni* to be the most abundant larval species every month of the year except December. *Polydora ligni* was also the most abundant larval polychaete in the Elbe Estuary, Germany (Giere 1968). The life cycle may be completed in 5 or 6 wk (about 2 wk in the plankton and about 3 wk to maturity following settlement). Some adults live for at least a year (Daro and Polk 1973).

In the New York Bight apex, we found *P. ligni* to be much more widespread and abundant during summer months than winter months (Fig. 40).

ADDITIONAL INFORMATION: Following the West Falmouth (Massachusetts) oil spill, *P. ligni* was the second most successful opportunistic species (following *Capitella capitata*). It settled primarily on muds or muddy sands but it is also known from hard substrata such as shells (Sanders et al. 1972). In the repopulation of the Raritan River Estuary following pollution abatement, *P. ligni* was among the most abundant colonists the first year and three subsequent years (Dean and Haskin 1964).

Spiophanes bombyx (Claparède, 1870)

DESCRIPTION: A discretely motile species which inhabits a sand tube lined with a fragile mucoid secretion. Body up to 60 mm long with 180 segments (Day 1967).

DISTRIBUTION: Worldwide (Hartman 1969).

HABITAT: Intertidal to 200 m. Kinner and Maurer (1978) reported *Spiophanes bombyx* to be one of the dominant species on the mid-continental shelf in the Delaware Bay region. Off southwest Long Island, *S. bombyx* was a dominant polychaete in the medium-coarse grain sand community (Steimle and Stone 1973). On Georges Bank it was the most abundant polychaete collected, increasing in density with higher percent sand and lower carbon content of sediments (Maurer and Leathem 1980). *Spiophanes bombyx* was also extremely abundant and widespread at New York-New Jersey outer continental shelf stations sampled by Pearce, Caracciolo, Halsey, and Rogers (1977a). In the New York Bight apex, *S. bombyx* was collected at almost all stations in all sediment types, and was the second most abundant polychaete in our study. It occurred most often in fine sand, low organic areas, and showed moderate abundance in fine to medium sand, with medium to high organic contents (Fig. 41; Table 1).

FEEDING ECOLOGY: The Spionidae are tentaculate, surface deposit feeders. Their guts contain many sand grains as well as detritus (Day 1967).

Wigley and Theroux (1965) stated that spionids are important in the diet of haddock.

REPRODUCTION AND GROWTH: Day (1967) stated that most spionids lay large eggs enclosed in tough egg capsules. Depending upon environmental conditions, these may be liberated directly into seawater so that all development takes place in the plankton (remaining in the plankton for as long as 3 mo), or they may be protected inside the burrow during early developmental stages. However, Hannerz (1956) believed development in *Spiophanes* spp. to be entirely pelagic. The larvae can, within limits, delay leaving the plankton until they find and settle on a suitable substratum.

ADDITIONAL INFORMATION: *S. bombyx*, known to be a tolerant species, often occurring in stressed environments, showed a marked increase in abundance during the 1976 New Jersey anoxic event (Steimle and Radosh 1979). Boesch et al. (1977) likewise found *S. bombyx* to be resistant to anoxia and found it to be oppor-

[9]J. L. Simon, pers. commun., cited by Grassle and Grassle (1974).

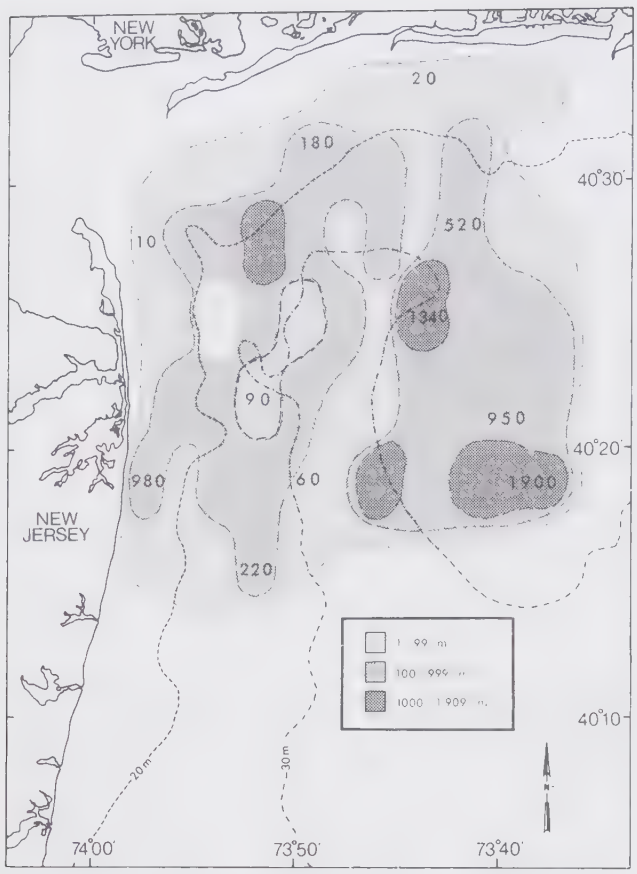

Figure 41.—Distribution and abundance of *Spiophanes bombyx* in the New York Bight apex.

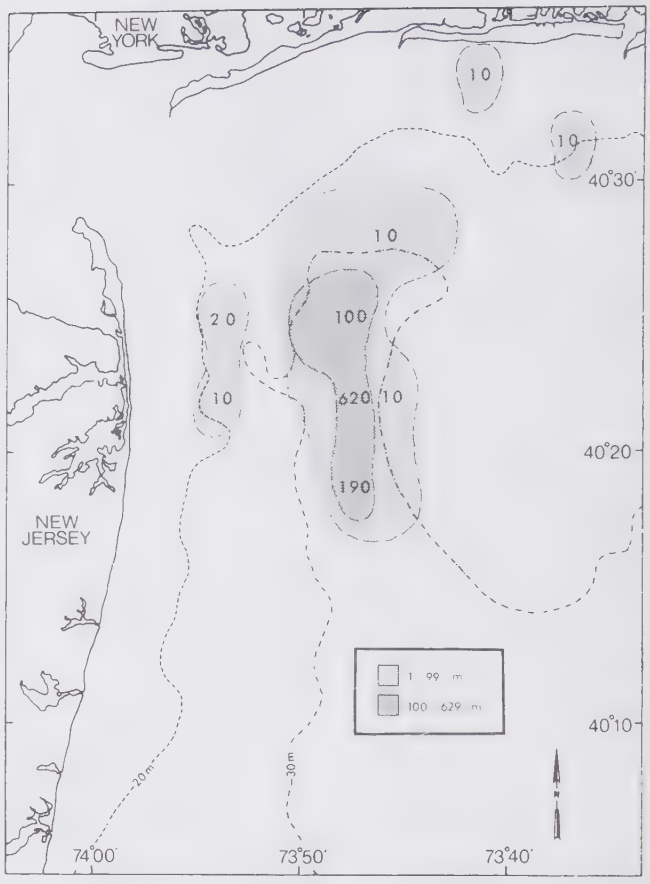

Figure 42.—Distribution and abundance of *Paraonis gracilis* in the New York Bight apex.

tunistic as well, showing substantial post-anoxic increases in population, possibly due to its capacity for rapid recolonization and its anoxia and sulfide tolerance.

***Paraonis gracilis* (Tauber, 1879)**

DESCRIPTION: Motile burrowers; body threadlike, length to 25 mm, width to 0.5 mm, segments to 100 (Pettibone 1963).

DISTRIBUTION: Cosmopolitan (Day 1967).

HABITAT: 5.4–2,002 m. Collected on bottoms of soft and sticky mud, muddy sand, mud with stones, gravel, and tubes (Pettibone 1963). In the New York Bight apex, *Paraonis gracilis* was almost always associated with fine sandy or silty sediments with high organic content (Fig. 42; Table 1).

FEEDING ECOLOGY: Paraonids burrow just below the sediment surface and are classified as nonselective deposit feeders (Dales 1963; Day 1967; Gosner 1971).

REPRODUCTION AND GROWTH: In August, in Maine, Pettibone (1963) has observed females of this species with large yolky, coral-pink eggs, about two per segment dorsally, and males with white sperm masses.

***Aricidea catherinae* (Laubier, 1967)**

[*Aricidea jeffreysii* (McIntosh, 1879)]

DESCRIPTION: Motile burrowers; length to 20 mm, width to 1.5 mm, segments to 120 (Pettibone 1963).

DISTRIBUTION: Ireland, Denmark, Mediterranean, Davis Strait to Delaware, North Carolina, Florida, western Canada (Gulf of Georgia) (Pettibone 1963; Day 1967).

HABITAT: Collected on bottoms of coarse to fine sand, sticky and soft mud, ooze, muddy sand, sand or mud with gravel, shells or tubes; 1.8 to 1,908 m depths (Pettibone 1963). On Georges Bank, *Aricidea catherinae* was abundant in coarse sand (Maurer and Leathem 1980). *Aricidea catherinae* was found in all sandy sediment types in the New York Bight apex, but was rare or absent in silt. They were uncommon in the highest organic areas, and were present in highest concentrations in low organic coarse sands (Fig. 43; Table 1). Conversely, in Delaware Bay, Kinner and Maurer (1978) found this species to be negatively correlated with an increase in grain size of sediments.

FEEDING ECOLOGY: The Paraonidae possess a simple proboscis for digging. They burrow just below the sediment surface

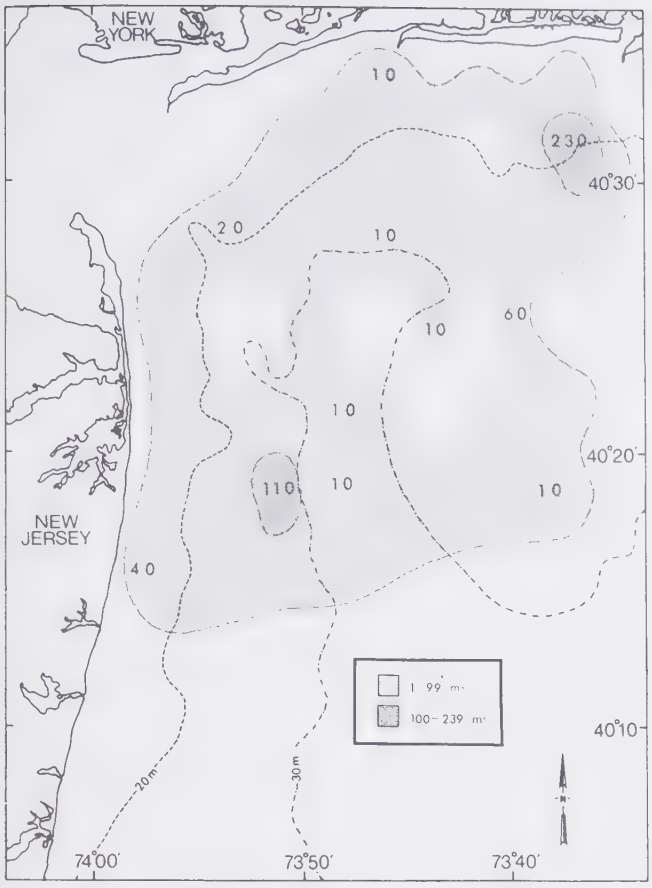

Figure 43.—Distribution and abundance of *Aricidea catherinae* in the New York Bight apex.

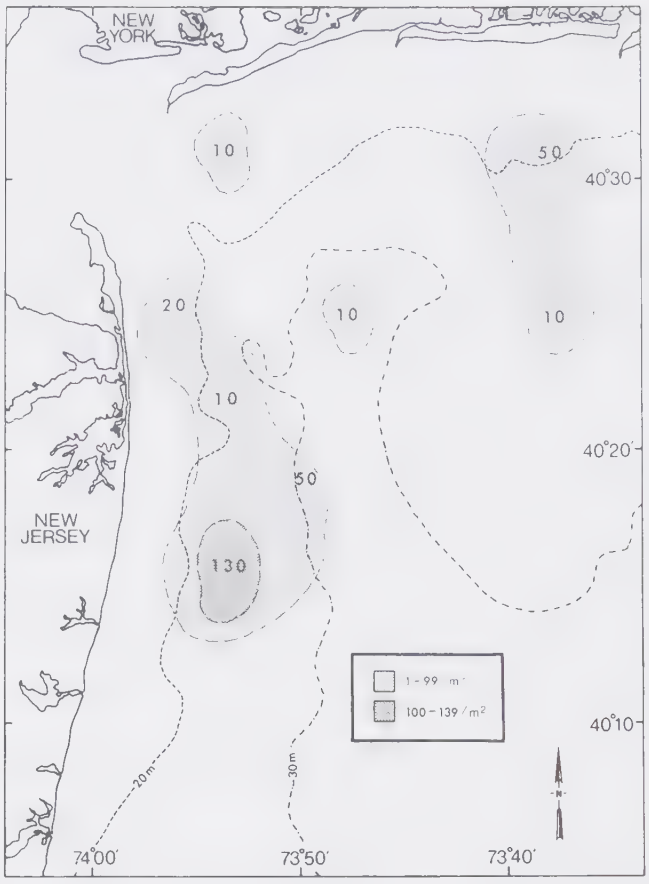

Figure 44.—Distribution and abundance of *Lumbrinerides acuta* in the New York Bight apex.

and are nonselective deposit feeders (Dales 1963; Day 1967; Gosner 1971).

Wigley (1956) has found *A. catherinae* in the stomachs of haddock off Georges Bank.

REPRODUCTION AND GROWTH: Pettibone (1963) has observed female *A. catherinae* massed with large yolky coral-pink eggs, and males with white sperm masses in Massachusetts during July. The large size of the ova indicates that the larvae are not pelagic. This agrees with Curtis' (1977) observation that *Aricidea suecica* (a related species), in Greenland, exhibits direct or lecithotrophic larval development.

Order Eunicida

Lumbrinerides acuta (Verrill, 1875)

DESCRIPTION: Motile burrowers; length to 40 mm, width to 1 mm, segments to 125 (Pettibone 1963; Jumars and Fauchald 1977).

DISTRIBUTION: Maine to New Jersey; southern California to western Mexico (Pettibone 1963).

HABITAT: Intertidal to about 185 m (Pettibone 1963); 16 to 450 m (Kinner 1978). Found at low water on mud and sand flats. Collected on bottoms of mud and coarse to medium sand (Pettibone 1963). In the Delaware Bay region, Kinner and Maurer (1978) found *Lumbrinerides acuta* to be one of the dominant species on the mid-continental shelf. There, it was associated with poorly sorted coarse sediments (>1 mm). In the New York Bight apex, except for one occurrence, *L. acuta* was absent from silty, high organic sediments, occurring in greatest abundance in coarse to medium, low organic content (<3%) sands (Fig. 44; Table 1).

FEEDING ECOLOGY: The Lumbrineridae are generally considered to be carnivorous, with some exceptions, but it is not known whether they are mainly predaceous or scavengers. The anterior end of the prostomium is richly supplied with nerves and the jaws are very powerful (Day 1967).

Lumbrinerides acuta has been found as a prey item in the stomachs of Georges Bank haddock (Wigley 1956).

REPRODUCTION AND GROWTH: No specific information was available for *L. acuta*. However, it probably exhibits nonpelagic development as do other lumbrinerids (see *Lumbrineris fragilis*, *Lumbrineris tenuis*, and *Ninoe nigripes*).

Lumbrineris fragilis (O. F. Müller, 1776)

DESCRIPTION: Burrowing, motile, length to 380 mm, width to 12 mm, segments to 340 (Pettibone 1963; Jumars and Fauchald 1977).

DISTRIBUTION: Arctic, Iceland, Faroes, Norway to Azores, Madeira, Mediterranean, Hudson Bay to North Carolina, Bering Sea, Alaska, north Japan Sea (Gardiner 1975).

HABITAT: Intertidal to 3,445 m. Found at low water on bottoms of mud, muddy sand, gravelly mud, and shifting sand. Collected on bottoms of sticky and soft mud, silty clay, various combinations of mud, sand, gravel, pebbles, stones, worm tubes, shells, and detritus (Pettibone 1963). In Kinner's (1978) study from Cape Cod to Cape Hatteras, *Lumbrineris fragilis* was a dominant species in sand on the inner and mid-shelf, and in silt-clay on the mid-outer shelf and slope. Greatest numbers occurred in medium, well-sorted sands. Steimle and Stone (1973) found *L. fragilis* to be a dominant species in medium-coarse grain sand off southwest Long Island. Similarly, in the New York Bight apex, *L. fragilis*, although present in all grades of sand, was most concentrated in medium-coarse sand with an organic content of <4%. It was absent from most stations with high organic contents or was present in very low numbers (10–20/m²) (Fig. 45; Table 1).

FEEDING ECOLOGY: *L. fragilis*, as other lumbrinerids, is considered a carnivore. Blegvad (1914) listed the gut content for *L. fragilis* as polychaetes, ophiuroids, nemerteans, small crustaceans, and bivalves.

Lumbrineris fragilis has been found as a prey item in the stomachs of cod and haddock (Pettibone 1963).

Tyler (1973) found no seasonal trend in caloric value for Canadian specimens; the annual mean was 4,565 g cal/g dry weight.

REPRODUCTION AND GROWTH: *L. fragilis* has been observed containing large eggs in August in the Woods Hole, Mass., area (Pettibone 1963).

Within the *Lumbrineris* population at Disko Fjord, Greenland, Curtis (1977) observed that large oocytes (200–250 μm) of *L. fragilis* were present at all times of the sampling interval (1959–60) indicating that the species produces larvae having a direct development. Yet, although most specimens were large and presumably mature, only about 20% of those sampled were involved in gametogenesis. This suggests that a large segment of this population did not reproduce. Thorson (1946) also considered that *L. fragilis* has a direct larval development as did Pettibone (1954), who collected nonpelagic larval lumbrinerids, tentatively identified as *L. fragilis*, at Point Barrow, Alaska, during September. These larvae were found in mucus masses, sometimes attached to the tunicate, *Boltenia echinata*.

Lumbrineris tenuis Verrill, 1873

DESCRIPTION: Body threadlike, length to 150 mm, width to 1 mm, segments to 200 (Pettibone 1963).

DISTRIBUTION: Maine to North Carolina, Gulf of Mexico (Gardiner 1975).

HABITAT: Intertidal to abyssal depths. Found at low water burrowing in mud and sand beneath stones, in compact sand mixed with mud, and in sandy mud flats close to the low water mark. Collected on bottoms of gravel with shells, mud, compact mixtures of mud and sand, various combinations of mud, sand, gravel, with sponges, shells, and amphipod and worm tubes. Common among

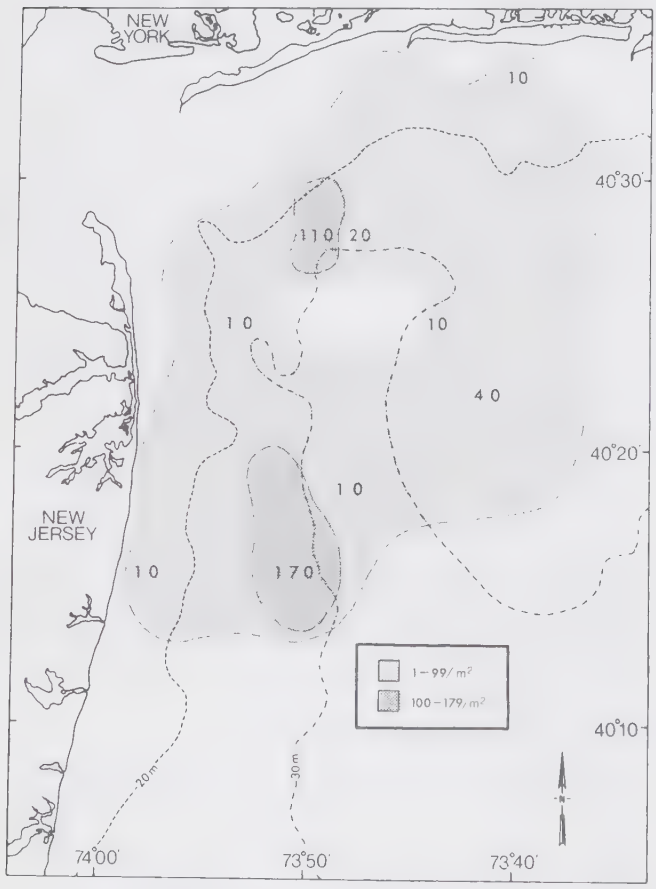

Figure 45.—Distribution and abundance of *Lumbrineris fragilis* in the New York Bight apex.

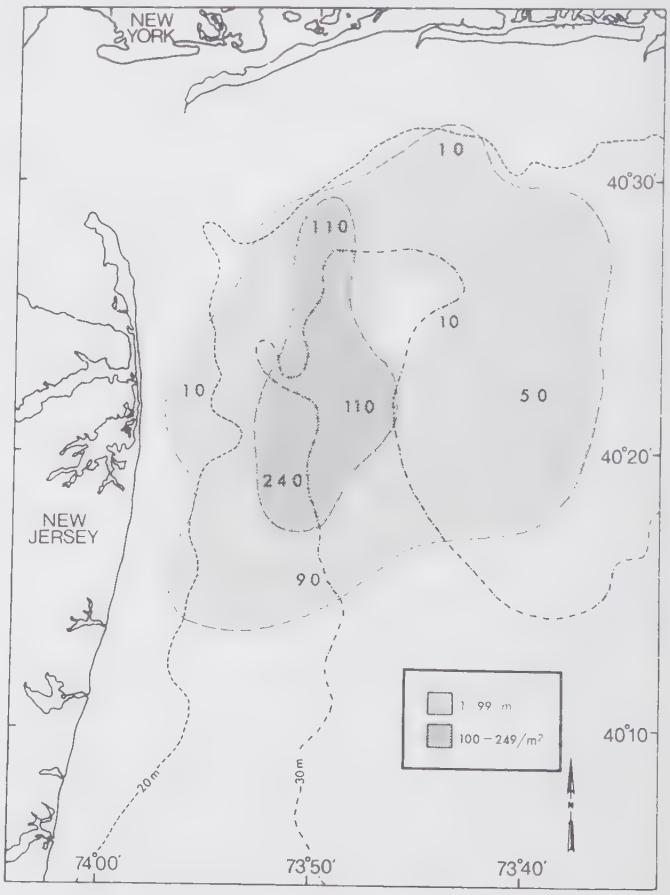

Figure 46.—Distribution and abundance of *Lumbrineris tenuis* in the New York Bight apex.

the sandy tunicates *Amaroecium pellucidum* (Pettibone 1963). *Lumbrineris tenuis* was abundant in samples collected on the New York-New Jersey outer continental shelf by Pearce, Caracciolo, Halsey, and Rogers (1977a). In the New York Bight apex, *L. tenuis* was present in all sediment types, occurring in high concentrations in a variety of sediments, particularly those with medium to high organic contents (Fig. 46; Table 1).

FEEDING ECOLOGY: The Lumbrineridae, in general, are thought to be carnivores, however, Sanders et al. (1962) found sand, diatoms, and detritus in the stomachs of *L. tenuis*, indicating that it may also be a deposit feeder.

In our collections, *L. tenuis* has been found in the gut of the polychaete *Tharyx acutus* on three occasions (Frame).[10]

REPRODUCTION AND GROWTH: Gelatinous egg masses with large, dull greenish yolky eggs have been found in the sand in Cuttyhunk Harbor, Mass., during June. Similar large yolky eggs were found inside some individuals found in the same area. Spherical gelatinous masses containing eggs and larvae were also observed attached to the surface of the mud (Pettibone 1963).

The early development of *Lumbriconereis* sp. from Newport, R.I., described by Fewkes (1883), may refer to this species. The eggs were found in all stages of growth in June, July, and August. Early development took place within the gelatinous egg masses, after which crawling, nonpelagic larvae emerged.

In Greenland, Curtis' (1977) collections of *Lumbrineris* spp. (tentatively identified as *L. tenuis* and *L. minuta*) included a number of females, often bearing coelomic oocytes of 150–250 μm. The appearance and size of the ripe ova seemed to him to be indicative of direct larval development. Spawning season could not be discerned.

Ninoe nigripes Verrill, 1873

DESCRIPTION: Motile, burrowing form; body elongate, slender. Length to 100 mm, width to 4 mm, segments to 150 (Pettibone 1963).

DISTRIBUTION: Gulf of St. Lawrence to Florida, Gulf of Mexico, Chile, off northwest Spain, Antarctic (Pettibone 1963; Gardiner 1975).

HABITAT: Intertidal to 1,170 m. Found at low water in mud. Collected on bottoms of soft or sticky mud, sandy mud, silty clay and fine sand, mud mixed with gravel, shells, and worm and amphipod tubes. *Ninoe nigripes* forms tubes of mucus mixed with mud and sand (Pettibone 1963). In Kinner's (1978) study from Cape Cod to Cape Hatteras, *N. nigripes* was one of the dominant species on the mid-outer shelf in silt-clay, occurring 43.8% of the time at stations with >10% silt-clay. In the New York Bight apex, *N. nigripes* occurred in high concentrations in a variety of sediment types and organic levels (Fig. 47; Table 1).

FEEDING ECOLOGY: The Lumbrineridae are generally considered to be carnivorous burrowers (Day 1967). However, Sanders (1960) found *N. nigripes* to be a selective deposit feeder, feeding on the surface of the mud.

[10]Ann Frame, Northeast Fisheries Center Sandy Hook Laboratory, National Marine Fisheries Service, NOAA, Highlands, NJ 07732, pers. commun. July 1978.

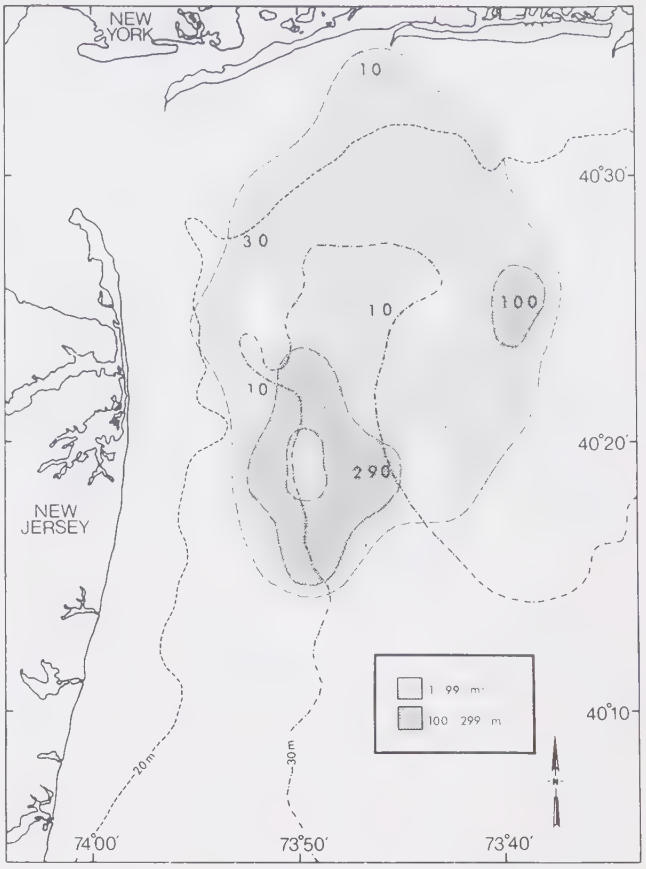

Figure 47.—Distribution and abundance of *Ninoe nigripes* in the New York Bight apex.

REPRODUCTION AND GROWTH: Males filled with white sperm masses and females with large orange yolky eggs ($\approx$160–190 μm in diameter) have been found in the Cape Cod Bay (Massachusetts) region in June, July, and August, along with numerous very small specimens. Among the specimens collected in Massachusetts Bay, fertilized eggs were present among parapodia in the branchial region. The yolky eggs were being extruded from large pores below the parapodia (Pettibone 1963).

Drilonereis longa Webster, 1879

DESCRIPTION: Body threadlike, length to 710 mm, width to 1.5 mm, segments to 1,000 (Pettibone 1963).

DISTRIBUTION: Massachusetts to Georgia, West Indies, Washington, southern California (Pettibone 1963; Gardiner 1975).

HABITAT: Collected on bottoms of fine sand, silty clay, or mud, with worm tubes or fine gravel from the intertidal to depths of 2,450 m (Pettibone 1963; Gardiner 1975). In Kinner's (1978) study from Cape Cod to Cape Hatteras, *Drilonereis longa* was a dominant species on the inner shelf in sand and on the mid-outer shelf in silt-clay. In the New York Bight apex, *D. longa* occurred in all sediment types, primarily in fine sands, being absent from only the highest organic areas (Fig. 48; Table 1).

FEEDING ECOLOGY: Members of this family (the Arabellidae) are burrowers and are generally considered to be predaceous or

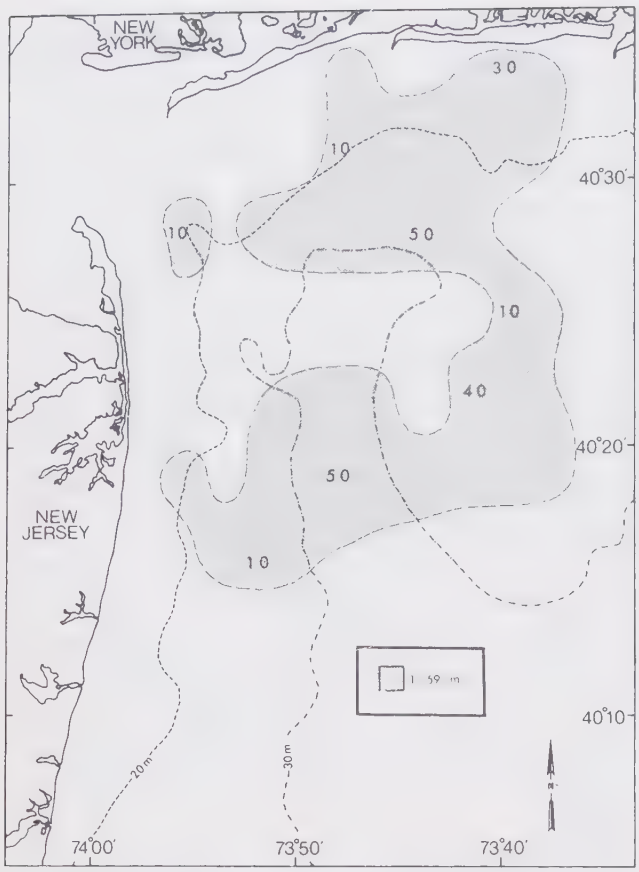

Figure 48.—Distribution and abundance of *Drilonereis longa* in the New York Bight apex.

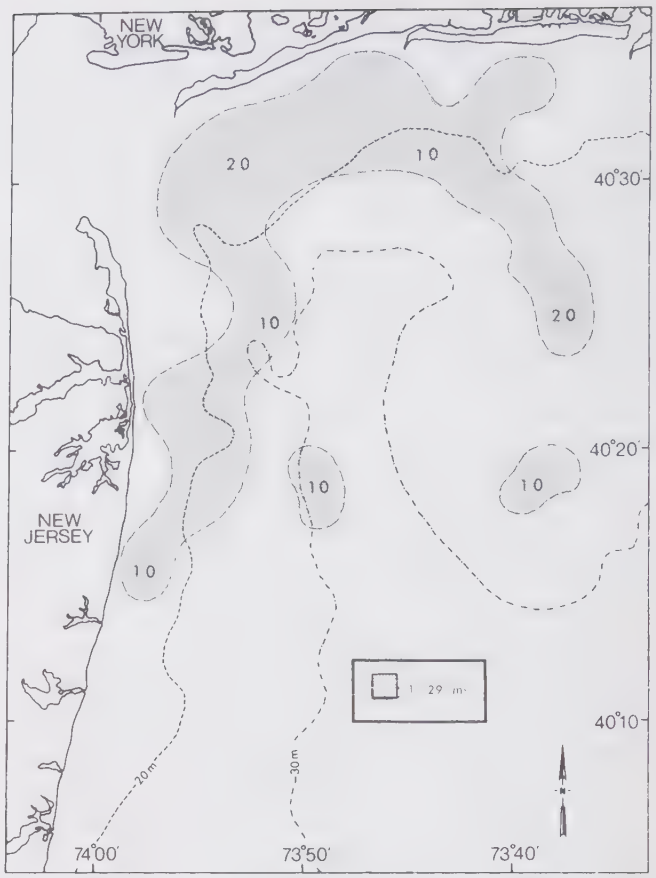

Figure 49.—Distribution and abundance of *Magelona* cf *riojai* in the New York Bight apex.

carnivorous (Pettibone 1963; Day 1967; Gosner 1971). However, Sanders et al. (1962) considered *D. longa* to be a sediment ingestor after finding sand, diatoms, and algae to be the main contents of its gut. It may be that *D. longa* exhibits both types of feeding behavior, each under different environmental conditions.

REPRODUCTION AND GROWTH: No information was found on the reproduction and growth of this species. However, planktonic larvae of this family (Arabellidae) were not found by Fewkes (1883), Thorson (1946), or Rasmussen (1956), and brooding has been recorded for another Arabellidae, *Notocirrus spiniferus*, (Pettibone 1957). These facts tend to support the idea that the Arabellidae exhibit nonpelagic development.

Order Magelonida

***Magelona* cf *riojai* Jones, 1963**

DESCRIPTION: A slender-bodied, small worm with a spadelike head.

DISTRIBUTION: Maine to North Carolina (Kinner and Maurer 1978).

HABITAT: Jones (1968) has observed that *Magelona* sp. lives in a well-sorted, high energy, sand environment. In the New York Bight apex, *Magelona* cf *riojai* was found in low numbers in fine to medium sandy, low organic areas (<3%), and was restricted to depths of <25 m (Fig. 49; Table 1).

FEEDING ECOLOGY: Jumars and Fauchald (1977) classify the Magelonidae as surface deposit feeders; Day (1967) and Jones (1968) believed them to be burrowers, using the spadelike head and large distensible proboscis to force their way through the substrate. They feed on microscopic debris, diatoms, organic particles, and small plants and animals. While feeding, *Magelona* sp. utilizes the papillae of its paired prostomial tentacles. Food material adheres to distal papillae and is transferred to more proximal papillae when a loop is formed by the tentacle; by repetition of this activity, food material is passed stepwise toward the mouth (Day 1967; Jones 1968).

REPRODUCTION AND GROWTH: Specimens of *M. rosea* (a closely related species) collected from Cape Cod, Mass., by Moore (1900)[11] during the latter part of August contained nearly ripe eggs in the middle segments of the body. Bhaud (1972) reported larvae of *Magelona* sp. present in the plankton of the Danish Oresund from January through May.

[11]Moore, J. 1900. The polychaetous annelids of the Woods Hole region. Unpubl. manuscr., 1032 p. U.S. Natl. Mus., Wash., D.C.

Order Cirratulida

Tharyx acutus Webster and Benedict, 1887

DESCRIPTION: Sluggish worms; threadlike bodies. Maximum size 15 mm by 2 mm; has a shallow, mucous-lined burrow (Webster and Benedict 1887).

DISTRIBUTION: Maine to Virginia.

HABITAT: *Tharyx acutus* was abundant in samples collected on the New York-New Jersey outer continental shelf by Pearce, Caracciolo, Halsey, and Rogers (1977a). It was also the most abundant polychaete collected in the New York Bight apex samples, occurring throughout the apex in all sediment types. Although it was most common in low organic areas, it was present in concentrations as high as 3,300/m² in high organic sediments (Fig. 50; Table 1).

FEEDING ECOLOGY: The cirratulids, in general, are surface deposit feeders, gathering food particles from the sea bottom by means of numerous grooved tentacular filaments (Dales 1963; Day 1967). However, in some of our Baltimore Canyon Trough samples (Radosh et al. footnote 8), specimens of *T. acutus* were observed to have consumed the polychaetes *Lumbrineris tenuis* and *Drilonereis magna* (Frame footnote 10).

REPRODUCTION AND GROWTH: No information is available for *T. acutus*, however, Gibbs (1971) studied *Tharyx marioni*, a closely related species, at Plymouth, England. He found that *T. marioni* is capable of spawning over several years, with females breeding for the first time in the second year of life. The main spawning season extends from late October to early November when water temperatures are between 10° and 12°C. As described by Dales (1951), *Tharyx* spp. larvae are bottom-living, nonpelagic, and lecithotrophic. Population densities are at their highest level just after spawning has taken place; in Plymouth, the highest densities recorded were approximately 100,000/m². At that time, juveniles of the previous year's brood composed about two-thirds of the population and were easily distinguished from the larger adult worms. During spring and summer, population levels gradually declined so that during the breeding season a mean density of only 33,000/m² was recorded, of which about 40% were breeding adults.

In the New York Bight apex, we observed *T. acutus* to be 1.6 times more abundant during winter months, which would indicate that this species may also breed here during fall or winter months.

Tharyx annulosus Hartman, 1955

DESCRIPTION: Slow-moving, threadlike worm, slightly smaller than *T. acutus*.

DISTRIBUTION: New England to tropical South America; South Africa (Day 1973).

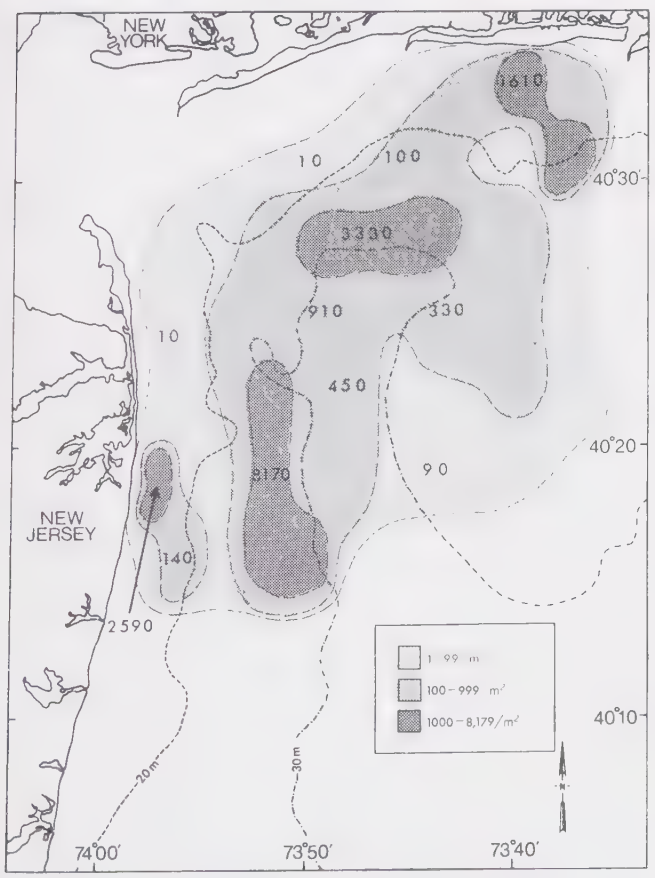

Figure 50.—Distribution and abundance of *Tharyx acutus* in the New York Bight apex.

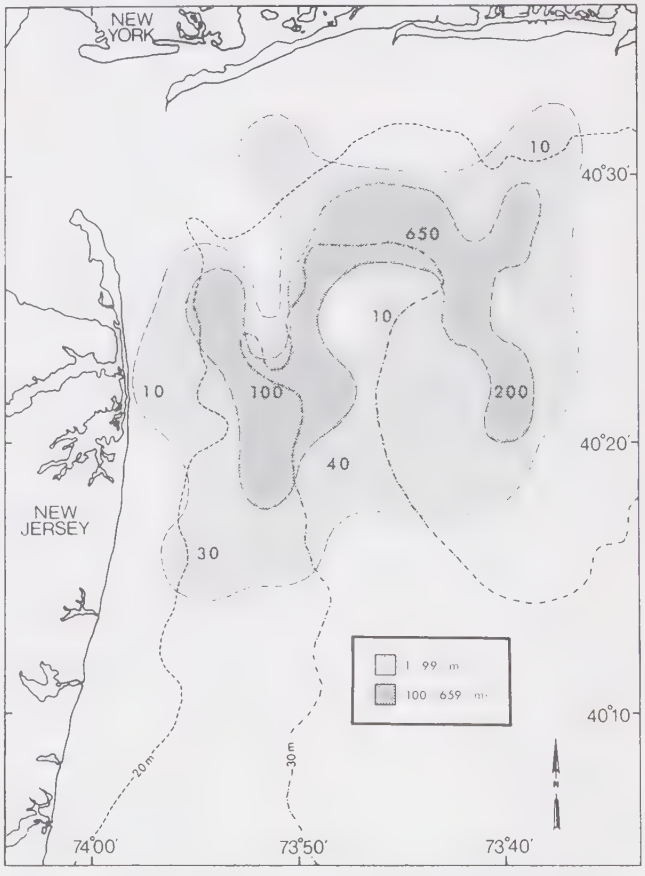

Figure 51.—Distribution and abundance of *Tharyx annulosus* in the New York Bight apex.

HABITAT: Collected in depths of 80–4,540 m (Day 1973). In the New York Bight apex, we found a few specimens of *Tharyx annulosus* in depths as shallow as 32 m, although the majority were found at greater depths. *Tharyx annulosus* was found in all sediment types, with largest numbers occurring in fine sand. Very high numbers were often found in sediments of high organic content but none were found at the station with the highest content of organic matter (13.9%). *Tharyx annulosus* was also present in large numbers in medium and low organic areas (Fig. 51; Table 1).

FEEDING ECOLOGY: *T. annulosus*, as other cirratulids, is a surface deposit feeder (see *Tharyx acutus* for details). However, in a New Jersey outer continental shelf sample, a specimen of *T. annulosus* was found to have eaten another polychaete of the genus *Lumbrineris* (Frame footnote 10).

REPRODUCTION AND GROWTH: In winter, there were 3.3 times more *T. annulosus* in the Bight than in summer, possibly indicating a fall or winter spawning period (see *T. acutus*).

***Caulleriella killariensis* (Southern, 1914)**

DESCRIPTION: Discretely motile, body threadlike, 8–12 mm long (Day 1973).

DISTRIBUTION: Ireland (Day 1973), New York Bight (Pearce, Rogers, Caracciolo, and Halsey 1977).

HABITAT: Reported from depths of 10–20 m (Day 1973). In the New York Bight apex, *Caulleriella killariensis* was present in depths up to 33 m in sediments ranging from coarse to fine sand. It was rarely present in sediments containing >3% organic material (Fig. 52; Table 1).

FEEDING ECOLOGY: *C. killariensis*, like other cirratulids, is a surface deposit feeder (see *Tharyx acutus*).

REPRODUCTION AND GROWTH: Gibbs (1971) reported *Caulleriella caput-esocis* to be capable of spawning over several years. He reported that the diameter of mature oocytes in Plymouth, England, was 110 μm and the main spawning season was from August to October. *Caulleriella caput-esocis* reached a maximum density of 22,000/m² in early summer. Females produced 1,000–5,000 oocytes.

In contrast to most species found in the New York Bight apex, which were present in greater numbers during summer months, *C. killariensis* was 2.3 times more abundant in winter than in summer in terms of more individuals at the same stations. This indicates that *C. killariensis* probably breeds here during fall or winter months (see *T. acutus*).

***Cossura longocirrata* Webster and Benedict, 1887**

DESCRIPTION: Small, threadlike, motile, burrowing form; length about 6 mm, 50–70 segments. A single, very long median

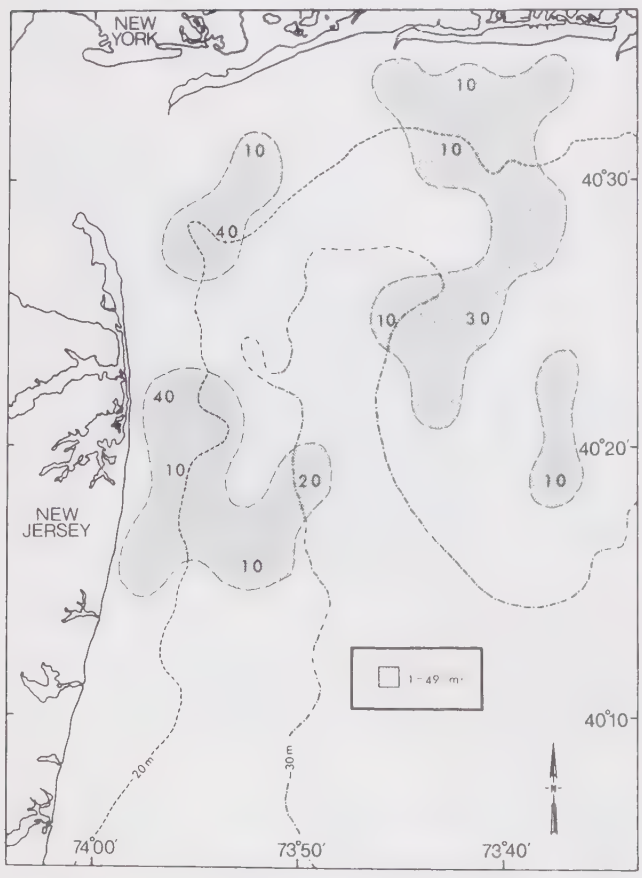

Figure 52.—Distribution and abundance of *Caulleriella killariensis* in the New York Bight apex.

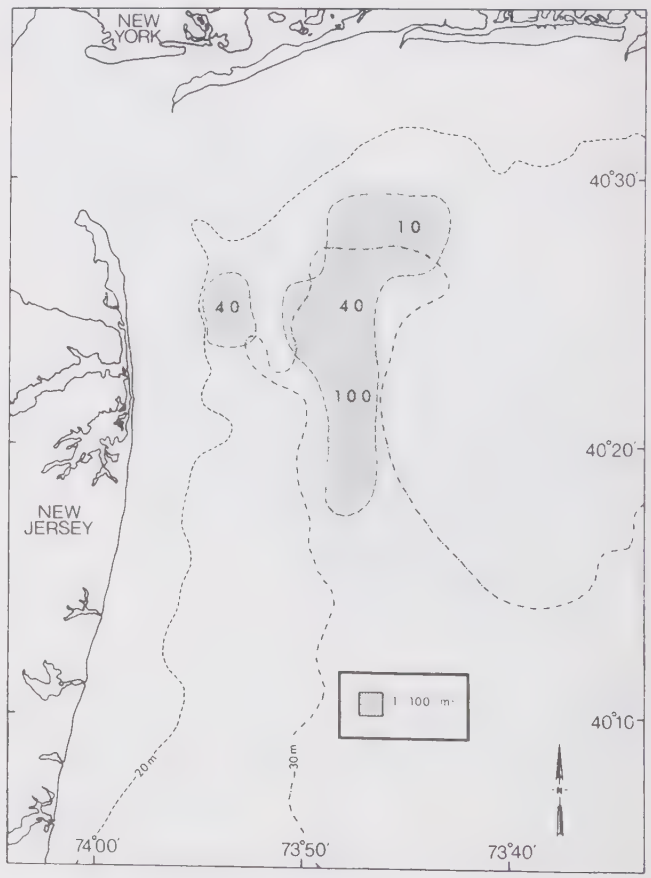

Figure 53.—Distribution and abundance of *Cossura longocirrata* in the New York Bight apex.

dorsal tentacle or gill originates on setiger four (Webster and Benedict 1887; Laubier 1963; Day 1967).

DISTRIBUTION: Listed by Gosner (1971) as a boreal species, found between Cape Cod and the Bay of Fundy. Also collected in the New York Bight and reported from Denmark, the North Atlantic, Greenland, the coast of Chile, and the Sea of Japan (Webster and Benedict 1887; Curtis 1977; Pearce, Rogers, Caracciolo, and Halsey 1977).

HABITAT: Inhabitant of mud and sandy mud in depths of 11–22 m (Webster and Benedict 1887; Day 1967; Gosner 1971). Fauchald (1977) says cossurids are common in sand and especially in deep slope abyssal muds.

In the New York Bight apex, *Cossura longocirrata* was collected in depths ranging from about 23 to 46 m. It was characteristic of the highest organic fine sandy and silty sediments (Fig. 53; Table 1). Summer and winter distributions were almost identical.

FEEDING ECOLOGY: Cossurids appear to be burrowing deposit feeders, using the eversible, soft, unarmed pharynx in feeding. The dorsal tentacle also appears to be sensory and, additionally, may be respiratory in function since it is well equipped with blood vessels (Day 1967; Fauchald 1977).

REPRODUCTION AND GROWTH: Curtis (1977) collected *C. longocirrata* in Greenland, however, no gametes were seen and the reproductive biology of the species remains unknown.

Order Terebellida

***Ampharete arctica* Malmgren, 1866**

DESCRIPTION: Tubicolous worms, inhabitating a membranous tube covered with mud, sand grains, or foreign matter (Day 1967; Gosner 1971). In our collections, length averaged 15–18 mm.

DISTRIBUTION: Cosmopolitan (Hartman 1969).

HABITAT: In the New York Bight apex, *Ampharete arctica* was collected in depths from 10.9 to 45.6 m. It was usually associated with fine to medium sandy sediments with low to medium organic content, although it did occur in low densities (10/m^2) in high organic areas (Fig. 54; Table 1).

FEEDING ECOLOGY: The Ampharetidae are sessile deposit feeders which gather food particles from the surface of sand or mud by means of buccal tentacles which can be extruded from the mouth (Day 1967; Jumars and Fauchald 1977).

Yablonskaya (1976) has found that the food of Ampharetidae from the Azov and Caspian Seas (U.S.S.R.) consists of flocculent organic-mineral particles with some remains of diatoms, blue-green and green algae. Most small ampharetids either collected particles of plant detritus from the sediment surface or filtered them from the water layer immediately above the sediment.

REPRODUCTION AND GROWTH: Little information was available on the reproduction and growth of *A. arctica*, however, Thorson (1946) stated that its wide distribution in Arctic seas indicated nonpelagic development because pelagic development is suppressed in nearly all Arctic species.

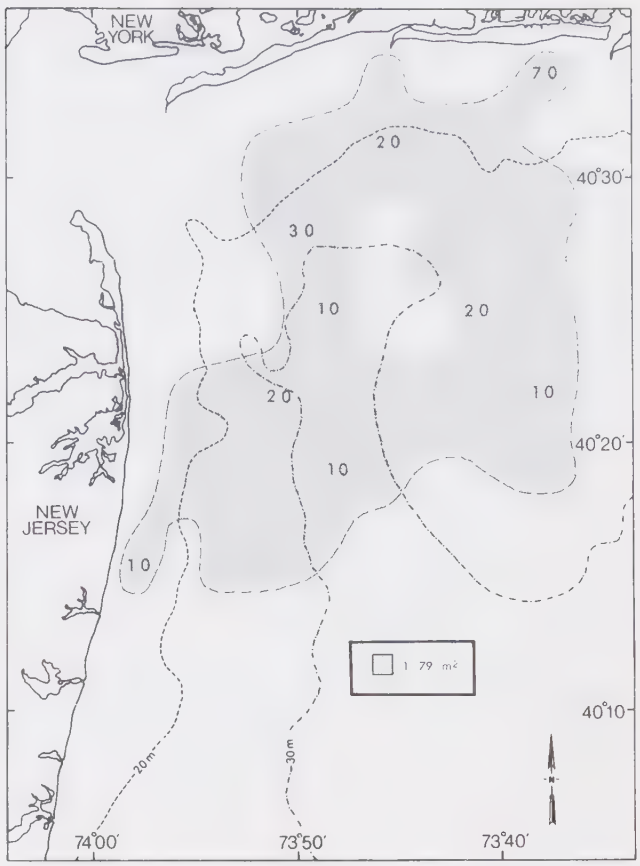

Figure 54.—Distribution and abundance of *Ampharete arctica* in the New York Bight apex.

Hutchings (1973) studied reproductive patterns of a related species, *Mellina cristata*. The Northumberland (England) population of *M. cristata* breeds annually over a period of about 2 wk at the end of December and beginning of January. Benthic larvae are produced which metamorphose into juveniles within 2 to 3 wk of spawning. *Mellina cristata* is potentially capable of breeding for the first time when 2 yr old. The majority of worms survive spawning and *M. cristata* probably breeds annually for several years. In this population, not all potential breeders spawn, some resorb their gametes and release another batch of gametes into the coelom. The Northumberland population of *M. cristata* is near the southernmost limit of the species distribution, which indicates that environmental conditions for this population are not optimum. The population appears to maintain itself by producing fewer oocytes and by only part of the population spawning.

***Asabellides oculata* (Webster, 1880)**

DESCRIPTION: Sessile worms, dwelling in membranous tubes. In our collections, lengths reached 20 mm.

DISTRIBUTION: Cape Cod to Cape Hatteras (Gosner 1971).

HABITAT: Depths of 5–15 m (Gosner 1971). In the New York Bight apex, we found *Asabellides oculata* in depths of about 10–46 m. It was present in all sediment types but reached peak abundance in fine sand. Its total abundance was highest in low organic areas, reaching moderate abundance in high organic areas. However, the

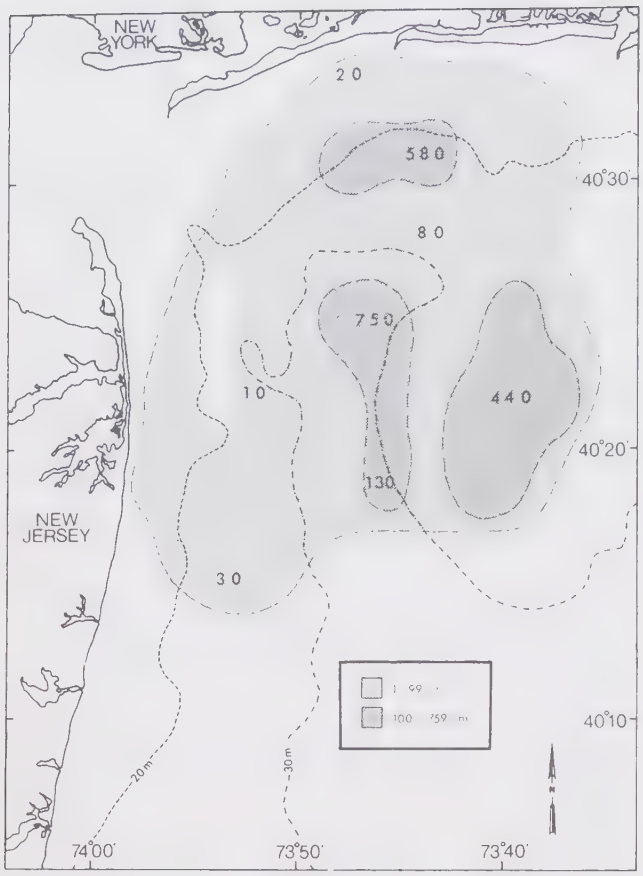

Figure 55.—Distribution and abundance of *Asabellides oculata* in the New York Bight apex.

highest concentration of *A. oculata* occurred at a high organic content station (Fig. 55; Table 1).

FEEDING ECOLOGY: *A. oculata*, like other Ampharetidae, is a surface deposit feeder (see *A. arctica*).

REPRODUCTION AND GROWTH: No specific information is available for *A. oculata* (see *Ampharete arctica*).

ADDITIONAL INFORMATION: It has been observed that *A. oculata* and several other tube dwelling polychaetes produce the enzyme protease externally. It is hypothesized by Zottoli and Carriker (1974) that this enzyme helps keep the internal surface of their tubes free of attaching organisms.

In recolonization studies during summer 1977, following the 1976 anoxic event in the New York Bight, "blooms" of *A. oculata* were observed in formerly oxygen depleted areas (Steimle and Radosh 1979). Although *A. oculata* is not generally regarded as an opportunist, we found it in highest concentration at a high organic station in the present study and we also found it in large numbers in an earlier unpublished study at an ocean sewer outfall off Deal, N.J. Fauvel (1958) remarked that the unusual pectinate gills found in this family (Ampharetidae) are adaptations for surviving in poorly oxygenated water.

Order Flabelligerida

Pherusa affinis (Leidy, 1855)

DESCRIPTION: A large, rather sedentary species characterized, in part, by the possession of mucus-secreting papillae to which sand or mud particles adhere. Lengths in our collections reached 75 mm.

DISTRIBUTION: Maine to Chesapeake Bay (Kinner and Maurer 1978).

HABITAT: *Pherusa affinis* has been collected in moderately high numbers from the New York-New Jersey outer continental shelf (Pearce, Caracciolo, Halsey, and Rogers 1977a). In a study of the New York Bight apex, Pearce (1972) found *P. affinis* to be more abundant around sludge deposits than in natural communties. In the present investigation of the apex, *P. affinis* was found in all sediment types but was again clearly most abundant in high organic fine sand and silty sediments, occurring in numbers as high as 800/m^2 (Fig. 56; Table 1).

FEEDING ECOLOGY: The Flabelligeridae are discreetly motile deposit feeders, using their large frilly palps to collect food particles from the sediment surface (Jumars and Fauchald 1977).

REPRODUCTION AND GROWTH: No specific information was available in the literature for this species. However, Fallon

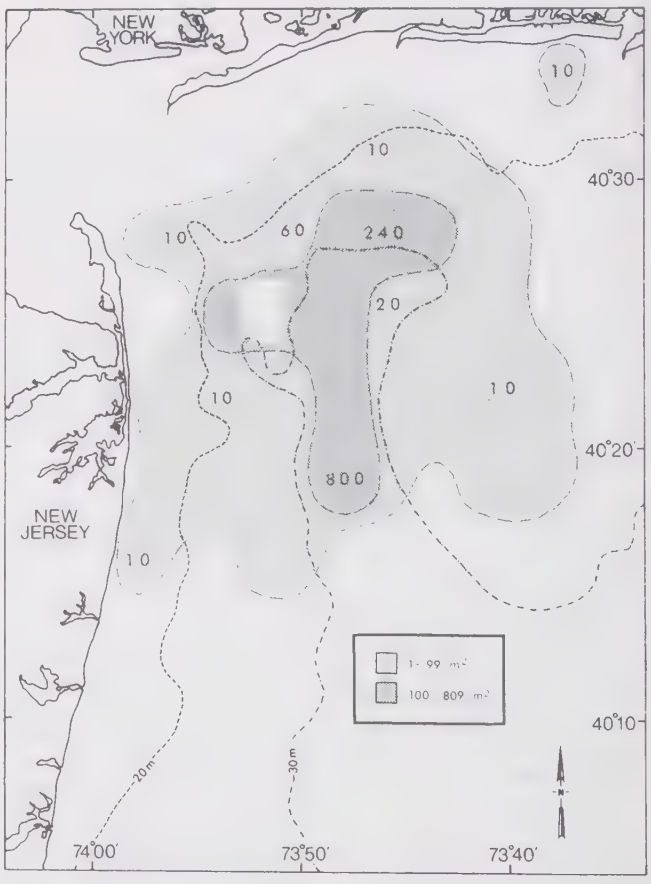

Figure 56.—Distribution and abundance of *Pherusa affinis* in the New York Bight apex.

(footnote 5) found the peak reproductive period for *P. affinis* in the New York Bight to be during spring and fall, with some recruitment almost all year. In our study of the apex, there were approximately 1.5 times more *P. affinis* in the Bight during summer months than during the winter in terms of higher densities at the same stations.

Phylum Arthropoda

Class Crustacea

Order Isopoda

***Edotea triloba* (Say, 1818)**

DESCRIPTION: The genus and species *Edotea triloba* has been revised to include the species *montosa* (Stimpson) and *acuta* (Richardson). It is a small, dorso-ventrally flattened, oval-shaped, muddy-colored isopod crustacean, which grows to about 10 mm in length (Miner 1950; G. Schultz 1969).

DISTRIBUTION: Miner (1950) reported that this species is distributed from Nova Scotia to New Jersey.

HABITAT: Smith (1964) reported that *E. triloba* is found on muddy shores, usually with dirt adhering to the carapace. Miner (1950) reported it from mud and fine sand from the surface to 46 m. In the New York Bight apex, *E. triloba* was widely distributed in depths ranging from about 9 to 46 m. It occurred in all sediment types but was most common in low organic fine to medium sands (Fig. 57; Table 1).

FEEDING ECOLOGY: Pearse et al. (1942) considered *E. triloba* a scavenger, Sanders (1956) classified it as a selective deposit feeder, and Myers (1977) called it an epistratal feeder.

G. Schultz (1969) reported finding *E. triloba* as a prey item in the stomachs of cod.

REPRODUCTION AND GROWTH: Sexes in isopods are separate. Eggs are brooded by the female in the marsupium. As in cumaceans and tanaidaceans, the hatching stage is a postlarva (manca stage), having the last pair of legs incompletely developed. The young usually do not remain with the female after they leave the marsupium (Barnes 1974).

Order Amphipoda

***Ampelisca verrilli* Mills, 1967**

DESCRIPTION: A small amphipod, males grow to 10.5 mm in length, females to 13.5 mm. Body compressed, smooth, two pairs of eyes. *Ampelisca verrilli* is a domiciliary form which constructs a shallow, thin-walled tube in sand. The tubes are open only at the upper end, the inner walls solidified by glandular secretions from the peraeopods (Bousfield 1973).

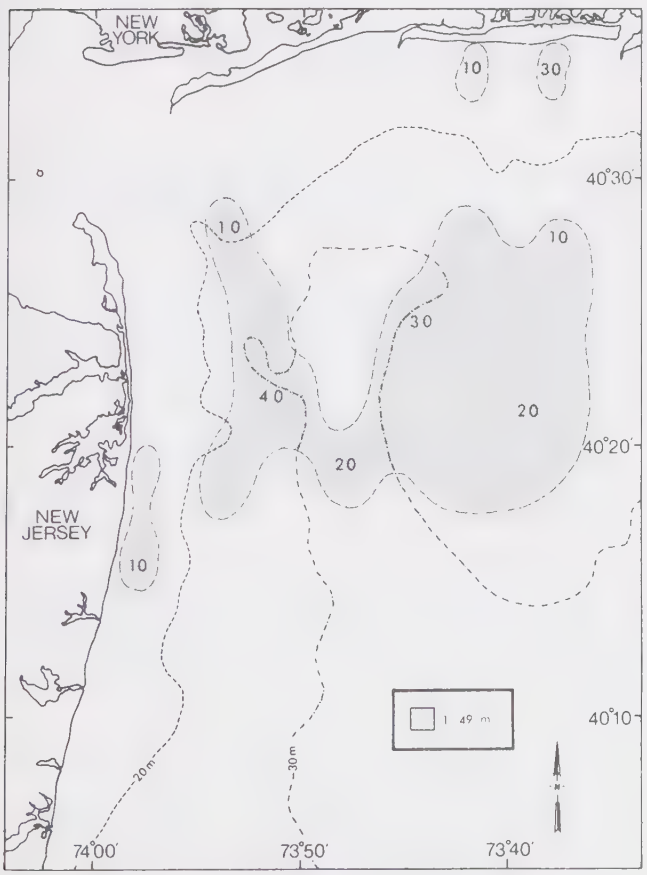

Figure 57.—Distribution and abundance of *Edotea triloba* in the New York Bight apex.

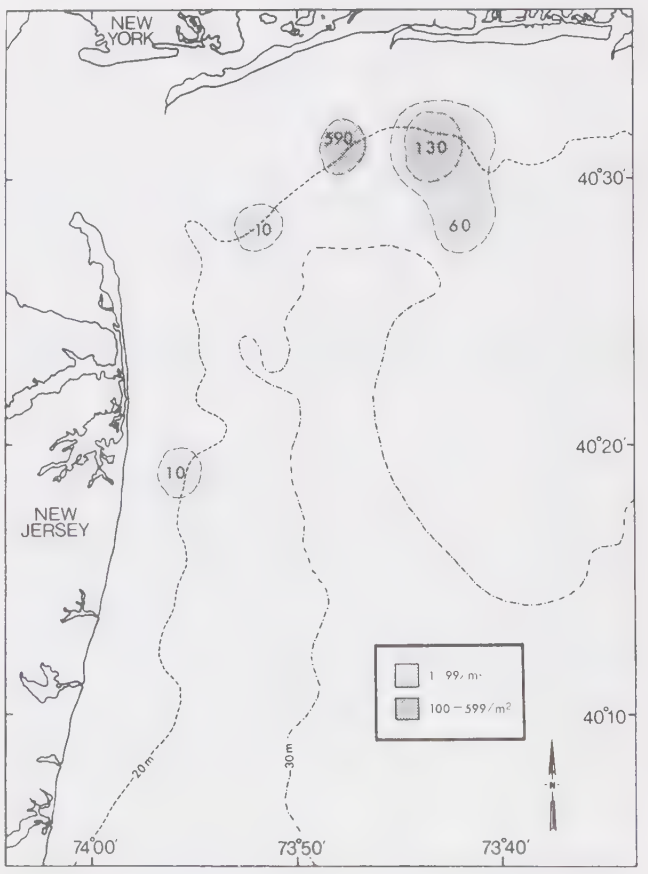

Figure 58.—Distribution and abundance of *Ampelisca verrilli* in the New York Bight apex.

DISTRIBUTION: Southern side of Cape Cod to North Carolina (Bousfield 1973); Gulf of Florida from Tampa north (Bousfield).[12]

HABITAT: Kinner et al. (1974) reported this species to dominate a transitional zone between sand and mud in Delaware Bay. Bousfield (1973) reported it to be abundant in coarse sand from low intertidal to depths of about 50 m. *Ampelisca verrilli* was the second most abundant amphipod collected in the New York Bight apex, most commonly found in fine sands with some occurring in medium sands off Long Island and New Jersey. This species was present only in low organic areas in depths to 24 m (Fig. 58; Table 1).

FEEDING ECOLOGY: *Ampelisca* spp. lie upside down in their tubes, projecting their setose antennae as filtering organs (Barnard 1969). *Ampelisca verrilli* has been classified as a suspension feeder-surface detritivore (Bousfield).[13]

REPRODUCTION AND GROWTH: Bousfield (1973) stated that *A. verrilli* has an annual life cycle in New England, with ovigerous females present in the summer. However, in a west Florida estuary, Thoemke (1977) found ovigerous females to be present year-round, averaging 9.6% of the population. He believed them to produce several broods per year. In view of these differences, temperature may be of importance in regulating the life cycle of this species.

In this family (Ampeliscidae), the mature male form emerges in abrupt metamorphosis from a femalelike penultimate stage (Bousfield 1973).

Unciola irrorata Say, 1818

DESCRIPTION: Smooth, slender, slightly depressed body with red spots or blotches when alive. Females grow to 10 mm, males to 13 mm. *Unciola irrorata* usually inhabits tubes constructed by other amphipods or polychaetes, but can build a tube of its own if no others are available (Bousfield 1973). Smith (1950) reported that these amphipods have been observed swimming or roaming across the bottom, leaving their tubes for considerable lengths of time.

DISTRIBUTION: Gulf of St. Lawrence to Cape Hatteras (Bousfield 1973); off South Carolina (Shoemaker 1945); also, Greenland, Norway (Holmes 1905).

HABITAT: Pratt (1973) and Maurer et al. (1976) included *U. irrorata* as a member of the silty sand fauna of the Middle Atlantic continental shelf and estuaries. Bousfield (1973) reported it to be found in coarse to medium sands from the lower intertidal to over 55 m in New England waters. Shoemaker (1945) recorded the species in depths to 283 m, Holmes (1905) recorded it to over 914 m and Schmitz (1959)[14] reported *U. irrorata* from muddy bottoms in North Carolina to depths of 1,500 m. Pearce (1972) found *U. irrorata* to be the only amphipod collected in the sewage sludge disposal area of the New York Bight apex. Michael (1973) called *U. irrorata* a cold water species which tolerates a wide range of sediment types, but prefers sand. The present collections in the Bight

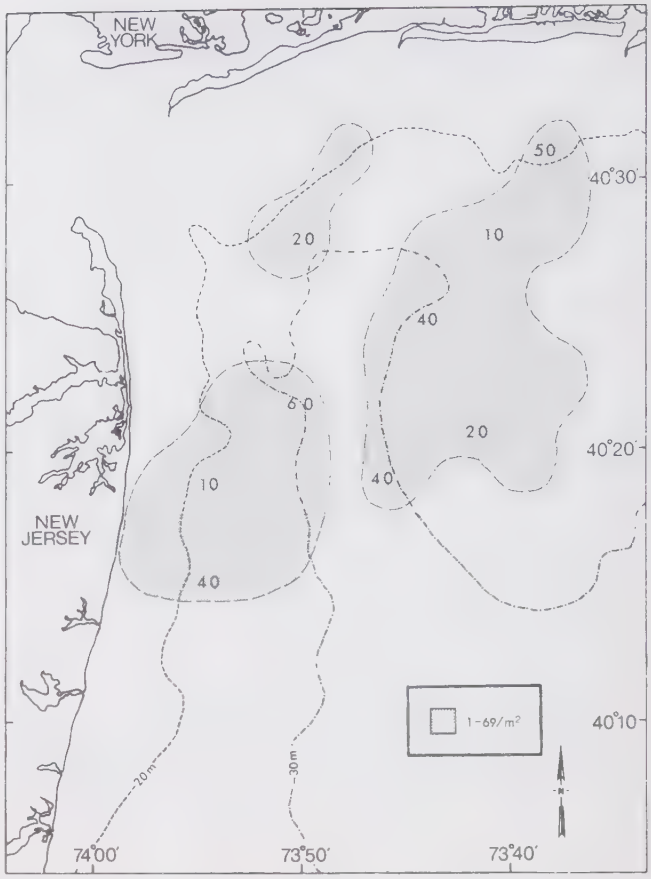

Figure 59.—Distribution and abundance of *Unciola irrorata* in the New York Bight apex.

apex show *U. irrorata* to occur in all grades of sand, particularly in fine sand and in low organic areas. *Unciola irrorata* was widespread in the apex, the third most abundant amphipod collected, occurring in depths to 33 m (Fig. 59; Table 1).

FEEDING ECOLOGY: Smith (1950) reported *U. irrorata* to be a scavenger and detritus feeder, while Sanders (1956) classified it as a selective deposit feeder, which may feed on detritus or be herbivorous. Enequist (1949) reported members of this family to be primarily filter feeders, emerging from their tubes and feeding on detritus whenever concentrations of suspended material are low.

Unciola irrorata is a principal forage species for haddock collected off Cape Cod and Georges Bank (Wigley 1956; Wigley and Theroux 1965).

REPRODUCTION AND GROWTH: Bousfield (1973) reported an annual life cycle off New England, with ovigerous females present from March to July; one brood per female. Smith (1950) stated that *U. irrorata* breeds 10–11 mo of the year in Block Island Sound, with mid-summer the minimal spawning season.

Pseudunciola obliquua (Shoemaker, 1949)

DESCRIPTION: Body smooth, slender, lacking eyes; length to 6 mm (Bousfield 1973).

DISTRIBUTION: Bay of Fundy to New Jersey (Bousfield 1973).

[12]Edward Bousfield, pers. commun., cited by Fox and Bynum (1975).

[13]Edward Bousfield, pers. commun., cited by Biernbaum (1979).

[14]Schmitz, E. 1959. A key to the marine Amphipoda of the Beaufort, North Carolina area. Unpubl. manuscr., 6 p. Duke Marine Laboratory, Beaufort, N.C.

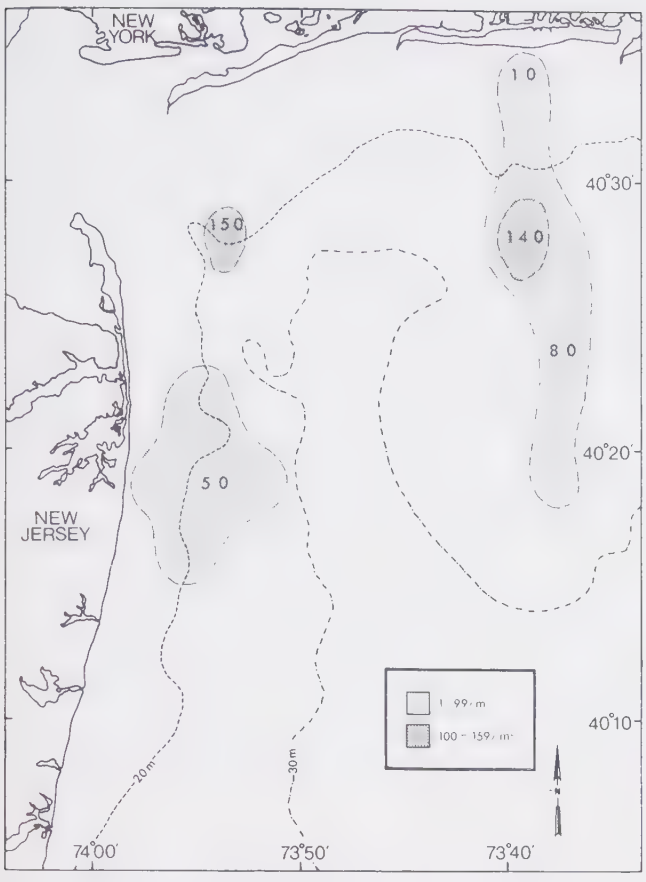

Figure 60.—Distribution and abundance of *Pseudunciola obliquua* in the New York Bight apex.

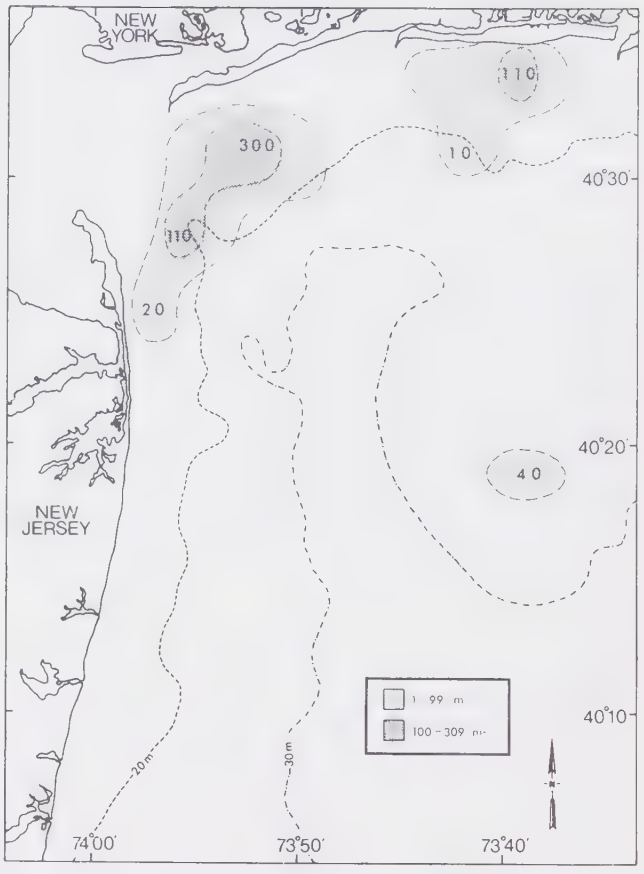

Figure 61.—Distribution and abundance of *Protohaustorius deichmannae* in the New York Bight apex.

HABITAT: Bousfield (1973) reported *Pseudunciola obliquua* to live in tubes in medium fine to coarse sand from just below the low water level to more than 50 m in depth off New England. In the New York Bight apex, *P. obliquua* was collected at several stations (9.6–25 m in depth) to the east and west of the dump sites. It was most common in fine-medium sands, but also occurred in coarse sand areas. *Pseudunciola obliquua* was collected only in low organic sediments (Fig. 60; Table 1).

FEEDING ECOLOGY: Mouthparts of *P. obliquua* are adapted for feeding on algae or detritus (Bousfield 1973).

Shoemaker (1949) found this species as a prey item in the stomachs of haddock.

REPRODUCTION AND GROWTH: Bousfield (1973) reported ovigerous females of this species off New England from April to August, with four–six relatively large eggs per brood. The life cycle is annual.

Protohaustorius deichmannae Bousfield, 1965

DESCRIPTION: A small, free-living, burrowing amphipod. Females of the species grow to 6 mm, but males are slightly smaller (4.5 mm) (Barnard 1969; Bousfield 1973).

DISTRIBUTION: Central Maine to Georgia (Bousfield 1973).

HABITAT: Bousfield (1973) reported that *Protohaustorius deichmannae* prefers shallow, warm water, protected bays and estuaries, depths up to about 20 m, and fine silty sand. This species was also considered characteristic of fine sand bottoms off the Delmarva Peninsula (Maurer et al. 1976). Sameoto (1969) reported a maximum lethal temperature of 36°C and migration of the species into deeper water as temperature decreases. *Protohaustorius deichmannae* is tolerant of low (10‰) salinity and low dissolved oxygen levels. In the New York Bight apex, we found *P. deichmannae* only in fine to medium grain, low organic sands in depths not exceeding 25 m (Fig. 61; Table 1). It was the most abundant amphipod collected during our study.

FEEDING ECOLOGY: Members of this family filter feed while burrowing through the sand. They use their mouthparts to set up a filter current that directs food particles onto mouthpart setae and then toward the mouth (Bousfield 1973). Sameoto (1969) reported this species to feed on diatoms, unidentified green/brown material, ciliates, and smaller crustaceans. According to Croker (1967), it would not feed on carrion.

REPRODUCTION AND GROWTH: *P. deichmannae* has an annual life cycle with ovigerous females found May to August in New England waters. There may be more than one brood per year, with brood size ranging from about 2 to 11 eggs. Copulation may take place in the substratum, mechanism as yet unknown (Sameoto 1969; Bousfield 1973).

Protohaustorius wigleyi **Bousfield, 1965**

DESCRIPTION: This species is very similar to *Protohaustorius deichmannae*, but is slightly larger, males reaching a length of 6.5 mm, females, 7.5 mm (Bousfield 1973).

DISTRIBUTION: Maine to North Carolina (Bousfield 1973).

HABITAT: Kinner et al. (1974) reported *Protohaustorius wigleyi* to be an important species in the sand bottom assemblage of Delaware Bay, closely associated with the bivalve *Tellina agilis* and the amphipod *Rhepoxynius epistomus*; *P. wigleyi* was the most abundant amphipod in clean medium grain sands off the Delaware coast (Maurer, Leathem, Kinner, and Tinsman 1979). Bousfield (1973) reported that it prefers subtidal clean sands off New England from the shoreline to over 146 m. In the New York Bight apex, *P. wigleyi* was most common near shore in depths up to 21 m. It occurred only in low organic sands, primarily of medium to fine grain size (Fig. 62; Table 1).

FEEDING ECOLOGY: See *Protohaustorius deichmannae*.

REPRODUCTION AND GROWTH: *P. wigleyi* has an annual life cycle in New England waters, with ovigerous females present from April to August (Bousfield 1973).

Leptocheirus pinguis **(Stimpson, 1853)**

DESCRIPTION: A relatively large gammarid amphipod with a long (up to 17 mm), slender body. *Leptocheirus pinguis* is an epifaunal organism, which constructs mucus and sediment tubes with one end open at the surface (Bousfield 1973).

DISTRIBUTION: American Atlantic coast from Labrador south to Virginia (Bousfield 1973); North Carolina (Fox and Bynum 1975).

HABITAT: Bousfield (1973) reported *L. pinguis* to occur from the low intertidal to >250 m, on sand, sandy mud, or mud bottom, especially in channels of estuaries. Michael (1973) reported this species to prefer cold water and intermediate, poorly sorted sediments. In the New York Bight apex, *L. pinguis* was found at five closely spaced stations south of the dump site. Sediments there are predominantly high organic silt-fine sand, with depths ranging from about 28 to 46 m (Fig. 63; Table 1).

FEEDING ECOLOGY: This filter feeding species uses filter setae of the anterior peraeopods from which food is transferred by maxilliped palps to the mouth (Sanders 1956; Bousfield 1973).

Leptocheirus pinguis is particularly important in the diet of haddock collected from Cape Cod and the south central portion of Georges Bank (Wigley 1956; Wigley and Theroux 1965). Smith (1950) also considered it to be the dominant food species for demersal finfish in Block Island Sound.

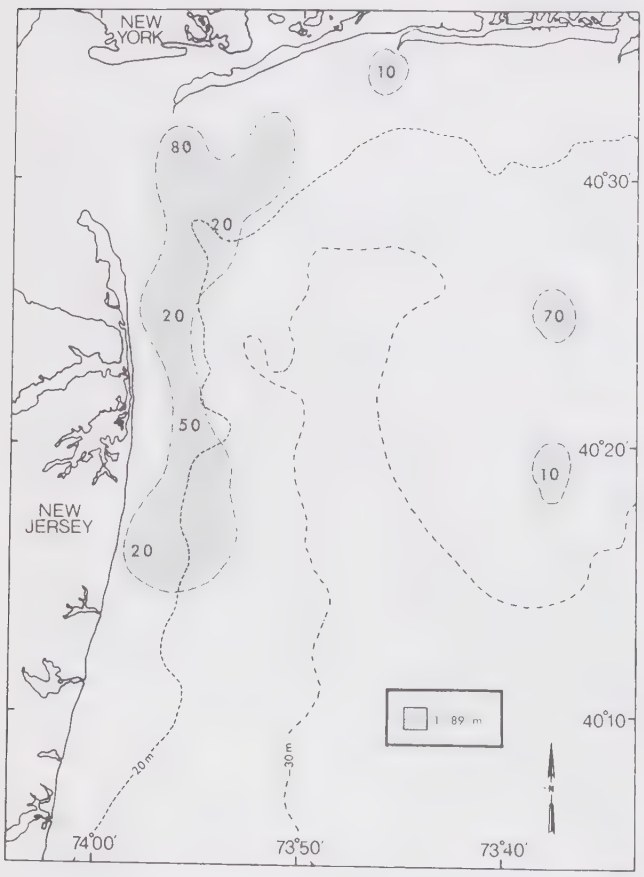

Figure 62.—Distribution and abundance of *Protohaustorius wigleyi* in the New York Bight apex.

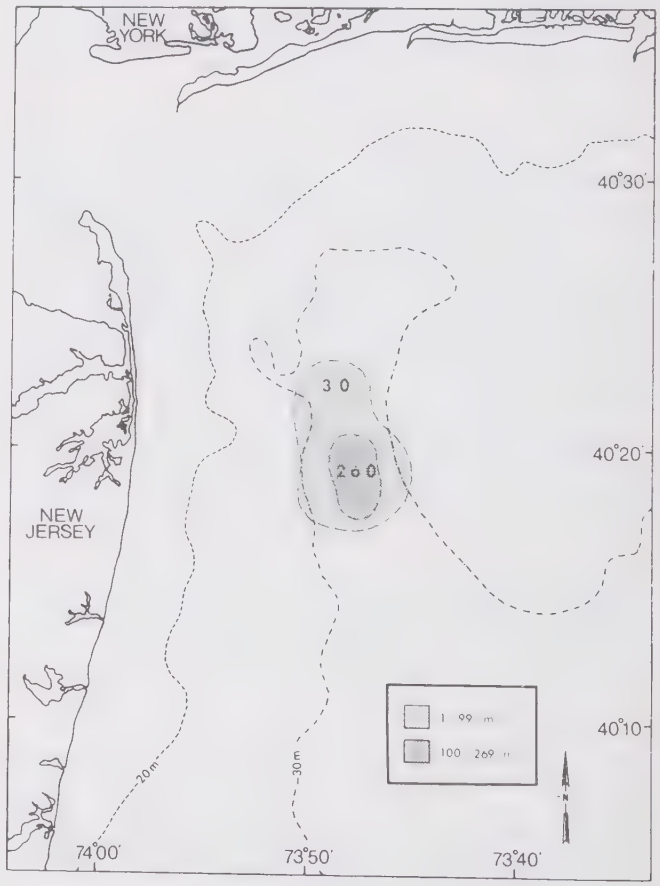

Figure 63.—Distribution and abundance of *Leptocheirus pinguis* in the New York Bight apex.

Tyler (1973) reported the species to have an average caloric value of 2.147 g cal/g dry weight, which is relatively low (2–50%) compared with values for other crustaceans.

REPRODUCTION AND GROWTH: Ovigerous females are present April to June in New England (Bousfield 1973). However, Smith (1950) believed spawning can occur throughout the year, with each female spawning more than once a year. The number of eggs per brood varies from a few to 70 ($\bar{x} = 20$). Bousfield (1973) stated that the life span of *L. pinguis* is probably 2 yr.

***Rhepoxynius epistomus* (Shoemaker, 1938)**

[*Trichophoxus epistomus* (Shoemaker, 1938)]

DESCRIPTION: A burrowing species, body relatively broad with a rostral hood abruptly narrowing in front of the black eyes. Females reach a length of 7–8 mm, with males slightly smaller (Barnard 1969; Bousfield 1973).

DISTRIBUTION: American Atlantic between southern Maine and Georgia (Watling and Maurer 1972; Bousfield 1973); also reported from Cuban waters (Ortiz 1978).

HABITAT: Kinner et al. (1974) reported *Rhepoxynius epistomus* to be dominant in sandy areas of Delaware Bay, closely associated with *Tellina agilis* and *Protohaustorius wigleyi*. Bousfield (1973) reported that it is found in medium-fine unstable sands off New England, from immediately subtidal areas to depths of >50 m; males occasionally occur in the plankton. Watling and Maurer (1972) stated that this species is euryhaline in medium to fine sands (5–15% silt-clay). Feeley (1967) suggested a preference for coarse sand. In the apex of the New York Bight, *R. epistomus* was characteristic of medium to fine sands, with a few occurring in coarse sand. It was most common in low organic areas in depths up to 30 m; a few occurred in medium organic areas and none were found in high organic sediments (Fig. 64; Table 1).

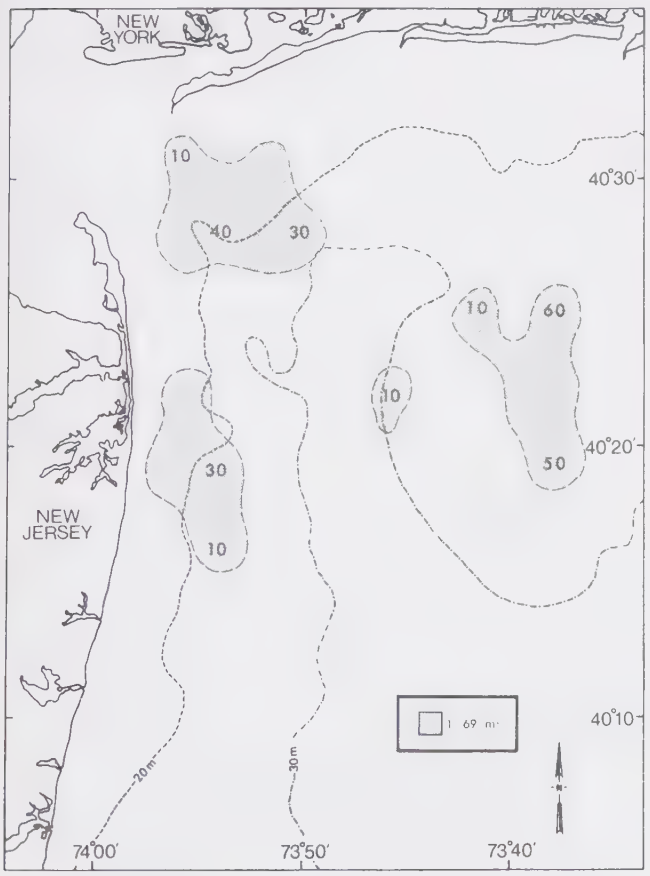

Figure 64.—Distribution and abundance of *Rhepoxynius epistomus* in the New York Bight apex.

FEEDING ECOLOGY: Barnard (1969) believed this species to be omnivorous, while Biernbaum (1979, citing Bousfield footnote 13) classified it as a burrowing detritivore.

REPRODUCTION AND GROWTH: Bousfield (1973) reported that *R. epistomus* has an annual life cycle, with ovigerous females present from May to September off New England. In this family (Phoxocephalidae), the mature male form emerges in abrupt metamorphosis from a femalelike penultimate stage.

Order Mysidacea

***Neomysis americana* (Smith, 1873)**

DESCRIPTION: The opossum shrimp; small shrimp-like crustaceans up to 12 mm in length; eyes on stalks (Gosner 1971).

DISTRIBUTION: Wigley and Burns (1971) reported this species to occur from the Gulf of St. Lawrence to Chesapeake Bay, however, Gosner (1971) extended its range south to Cape Hatteras.

HABITAT: *Neomysis americana* is the most common euryhaline mysid shrimp inhabiting the estuaries and coastal waters of the northeastern United States. Wigley and Burns (1971) regarded it as a shallow water species most commonly reported from the intertidal zone to depths of 60 m; Gosner (1971) reported it in depths up to 214 m. *Neomysis americana* is essentially a bottom dweller during the day, but undertakes regular vertical migrations to the surface during darkness (Herman 1963).

In the apex of the New York Bight, this species was collected nearshore in depths to about 24 m and was most abundant in low organic fine sands (Fig. 65; Table 1). Because the Smith-McIntyre grab sampler is not a particularly good sampling device for this highly motile species, our estimates of its abundance and distribution are probably very poor.

FEEDING ECOLOGY: The food of mysids consists of small plankters or bottom forms as well as detritus filtered from currents set up by the thoracic limbs, thus, mysids might be considered to be omnivorous (Smith 1950; Clutter 1967; Richards and Riley 1967; Gosner 1971).

Stickney et al. (1975) found that the estuarine sciaenid, *Cynoscion regalis*, fed heavily on *N. americana* in the southeastern United States; of a total of 120 fish examined, *N. americana* occurred in 55% of their stomachs. *Neomysis americana*, which is often known to live in large swarms, also forms an important part of the diet of shad, flounder, and haddock (Wigley 1956; Barnes 1963).

REPRODUCTION AND GROWTH: The sexes are separate and there is external dimorphism in this species. Females have a brood pouch and development of young is direct, occurring within the

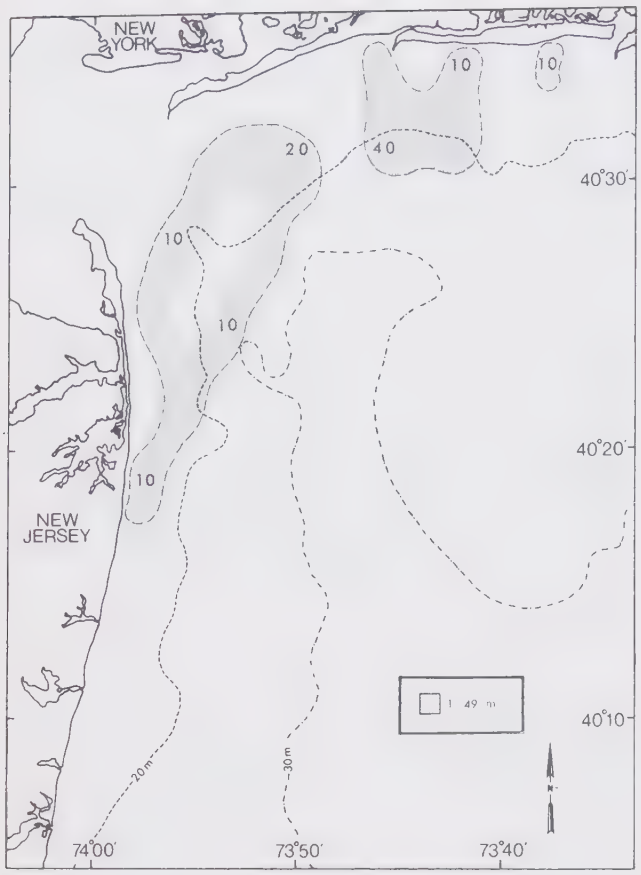

Figure 65.—Distribution and abundance of *Neomysis americana* in the New York Bight apex.

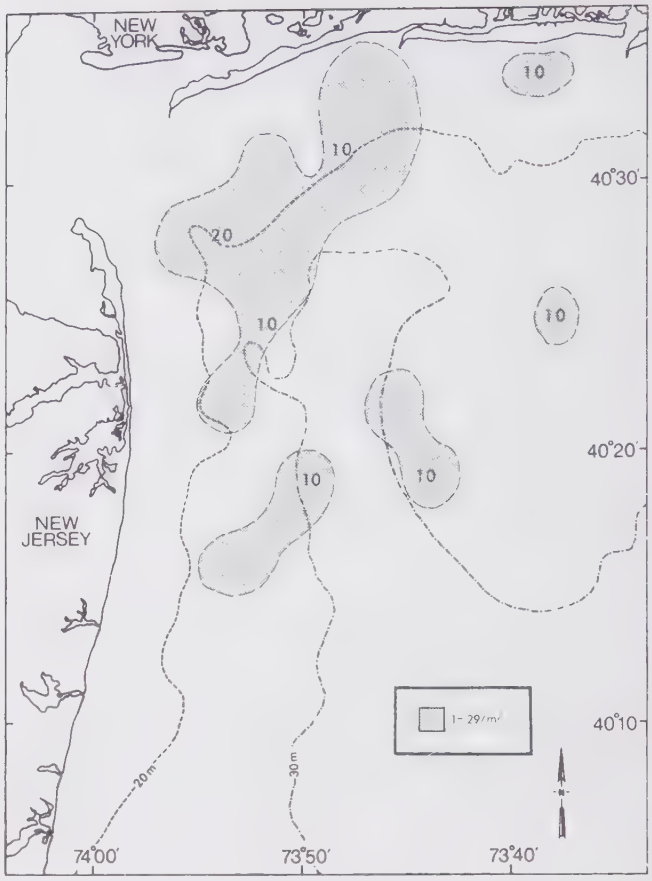

Figure 66.—Distribution and abundance of *Crangon septemspinosa* in the New York Bight apex.

brood chamber (Barnes 1963; Gosner 1971). Wigley and Burns (1971) reported that although spawning in coastal populations takes place throughout the year, it is much more intensive during the warmer months. Two distinct size groups of spawning females per year are discernible, the large spring spawners (11–12 mm) that have overwintered and smaller fall spawners (6–8 mm). Egg production also varies between the two groups, the overwintering group producing about 26 eggs/individual and the summer group about 6 eggs. The life cycle is a year or less and varies per seasonal population. Richards and Riley (1967) have estimated a production to biomass ratio of 3.66 for this species in Long Island Sound.

Order Decapoda

Crangon septemspinosa (Say, 1818)

DESCRIPTION: The common sand shrimp. Color ash-gray with numerous irregular, stellate, black or brown spots or chromatophores, or speckled with gray, imitating the color of sand. Length to 70 mm (Price 1962; Williams 1965).

DISTRIBUTION: In the Atlantic it occurs from Baffin Bay, Canada, to eastern Florida. It also occurs from Alaska to California on the Pacific coast and in Japan (Williams 1965).

HABITAT: *Crangon septemspinosa* occurs in great numbers from the littoral zone to depths of 91 m. It is common on sand flats, in tidepools, in bays and inlets along the coast, and in sandy bottoms in deeper water offshore. Its color imitates that of sand so closely that it is camouflaged when resting motionless on the bottom or when partially buried in the sand. Between tides, it uses its pleopods to bury itself in the moist sand to a considerable depth (Miner 1950; Williams 1965). *Crangon septemspinosa* can tolerate a salinity range of 4–32‰ and temperature extremes from 0.0° to 26.0°C (Price 1962).

In the New York Bight apex, *C. septemspinosa* occurred in low abundance, 10–20/m², in depths from 9.6 to 29.8 m. It was collected in all grades of medium and low organic content sand, but was most abundant in low organic fine-medium grain sand (Fig. 66; Table 1).

FEEDING ECOLOGY: Price (1962) considered this species to be an omnivore in Delaware Bay. Williams (1965) reported that it consumes planktonic crustacea and scavenged material. Sanders et al. (1962) found that *C. septemspinosa* ate detritus, diatoms, small crustacea (ostracods), small mollusks (*Gemma gemma*), nematodes, and algae in Long Island Sound. Wilcox and Jeffries (1974) found the species to prefer and grow best on animal tissues of marine origin although it was also able to utilize food of microbial and terrestrial origins.

Creaser (1973) stated that spent epitokes of the bloodworm, *Glycera dibranchiata*, are consumed by *C. septemspinosa*, which in turn is eaten by the striped bass, *Morone saxatilis*. *Crangon septemspinosa* must utilize all of its powers of concealment, for it is actively sought and consumed by nearly all of the larger fishes which frequent its waters. It constitutes a principal food for weakfish, *Cynoscion regalis*; kingfish, *Menticirrhus saxatilis*; bluefish,

Pomatomus saltatrix; flounders (*Paralichtys dentatus* and *Pseudopleuronectes americanus*); striped bass, *Morone saxatilis*; and haddock, *Melanogrammus aeglefinus* (Whiteley 1948; Miner 1950; Wigley 1956).

REPRODUCTION AND GROWTH: Price (1962), studying the biology of *C. septemspinosa* in Delaware Bay, made collections in a salinity range of 4.4 to 31.4‰ at temperature extremes of 0.0° to 26.0°C. The major breeding season was judged to be March to October, but ovigerous females were found throughout the year in salinities of 17.7–29.3‰ and temperatures of 0.0°–25.0°C. He found females to mature in 1 yr, with egg production increasing with increasing size of the female. First egg bearers of the year were found to be large females, with smaller ovigerous females more numerous in July. An average of 300 eggs/female was produced in one annual brood. In Maine waters, Haefner (1972) suggested that there may be more than one brood per year. In the laboratory, eggs hatched into planktonic larvae after 6 or 7 d at 21°C. Fowler (1912) reported that larvae and young maintained a planktonic existence for a long period of time after hatching.

Females outnumbered the males especially during the most active spawning season in Price's (1962) study. Growth rate was estimated to be 1.6 mm/mo, with no observed seasonal variation in the rate. Richards and Riley (1967) also reported growth rates of 1.6 mm/mo in Long Island Sound. However, Wilcox and Jeffries (1973) found that growth was temperature dependent and varied between 0.4 and 1.1 mm/wk off Rhode Island.

Contrary to the appraisal of other authors, Price (1962) judged that three year classes of females and two year classes of males occur in the shoal waters of Delaware Bay in spring.

Ovigerous females have been found in North Carolina from December through May and August and late fall (Hay and Shore 1918). Individuals taken in winter are larger than those found in spring. Juveniles have been found there from December to July, but from mid-summer to late fall, juveniles and adults disappear from North Carolina estuaries.

Bigelow and Sears (1939) reported much the same pattern of occurrence in waters of the continental shelf from Cape Cod to Chesapeake Bay, with greatest occurrence in February dwindling to rare occurrence in July, but never abundant anywhere.

On Georges Bank, where Whiteley (1948) made all collections inside the 100-fathom curve, *C. septemspinosa* was most common in September and January, rarest in June, and usually occurred near the bottom. He reported maximum numbers in July at Woods Hole, and in August in the Bay of Fundy. Ovigerous females were found in spring and early summer. The species was judged to produce one brood a year and to have a life span of 1 yr.

In Long Island Sound, *C. septemspinosa* had mean abundances of 12/m² in July 1972, 1/m² in April, and 8/m² in September 1973 in grab samples taken in mud bottom areas. The species had similar abundances in sands ($\bar{x}$ = 5/m² in July 1972 and 16/m² in September 1973), and was slightly more common in sandy silts (18/m² in July 1972, 22/m² in September 1973) (Reid et al. 1979). In an April through September 1971 survey in the western Sound, using an epibenthic sled, both larvae and adults were most abundant in July and August (National Marine Fisheries Service 1972).[15]

Fish (1926) found the larvae appearing from February to May and as late as December at Woods Hole, Mass. Needler (1941) recorded hatching times from late spring to early summer (July) around Prince Edward Island, Canada. She described five larval stages and a postlarval stage. All these stages were obtained in July from plankton tows made about a meter below the surface along the shores of estuaries. Larvae were hatched in the laboratory, but the series of stages was worked out from plankton samples.

These data indicate an extended breeding season in high latitudes. Variations in seasonal abundance in different localities north of Chesapeake Bay are possibly the result, in part, of varied sampling methods in different years by different investigators.

ADDITIONAL INFORMATION: In acute toxicity bioassays with $CdCl_2 \cdot 2\frac{1}{2}H_2O$ at 20°C and 20‰, Eisler (1971) found that the concentration, fatal to 50% of the organisms of various marine species in 96 h, ranged between 0.32 and 55.0 mg/l Cd^{2+}. *Crangon septemspinosa*, at 0.32 mg/l, was most sensitive of the species tested.

In a study of acute toxicities of insecticides on marine decapod crustaceans, Eisler (1969) again found *C. septemspinosa* to be the most sensitive to 12 insecticides tested.

In studies of color discrimination among crustaceans, it has been observed that the chromatophores of *C. septemspinosa* adapt to a background of yellow, orange, and red, chromatophore changes being mediated through the eyes (Barnes 1963).

Cancer irroratus (Say, 1817)

DESCRIPTION: The rock crab. The carapace reaches a length of 65 mm (Williams 1965) and a maximum reported width of 160 mm (Gosner 1971); it is yellowish in color, closely dotted with dark purplish brown, becoming reddish brown after death. The anterolateral border is divided into nine teeth with margins granulate, not denticulate as in *Cancer borealis*. Crabs of the genus *Cancer* have been in existence since the Eocene epoch; today, there are 19 living species in the world (MacKay 1943).

DISTRIBUTION: Labrador to South Carolina (Williams 1965); Jeffries (1966) listed the southernmost limit as Florida.

HABITAT: Collected from the intertidal zone to depths of 574 m (Williams 1965). *Cancer irroratus* prefers sandy or rocky substrates, but has also been found on mussel beds (Jeffries 1966; Scarratt and Lowe 1972; Winget et al. 1974; Krouse 1976; Reilly and Saila 1978). In general, smaller individuals are found inshore and larger individuals inhabit offshore areas (Scarratt and Lowe 1972; Haefner 1976; Krouse 1976). For example, Haefner (1976), in a study of the Middle Atlantic Bight, found that rock crabs <50 mm in size were most abundant in depths of 15–150 m, and larger crabs (50–100 mm) were generally more common in depths of 150–400 m, however, the largest individuals (>100 mm) were most abundant at 20–60 m.

The preferred temperature range of *C. irroratus* is reported to be 6.8°–14°C, however, they are known to inhabit areas of 3°–20°C (Jeffries 1966). Salinities ranging from 14 to 33‰ are tolerable (Winget et al. 1974; Haefner and Van Engel 1975).

In cooler New England waters, larger individuals may emigrate into deeper, warmer offshore waters during winter (Jeffries 1966; Krouse 1976).

In the New York Bight apex, small *C. irroratus* were collected in depths ranging from about 11.5 to 29.8 m. They were found in all sediment types, but were most common in low organic medium-fine grain sands (Fig. 67; Table 1).

[15]National Marine Fisheries Service. 1972. Davids Island Phase I: A short-term ecological survey of western Long Island Sound. Middle Atlantic Coastal Fisheries Center Informal Rep. 7, 29 p.

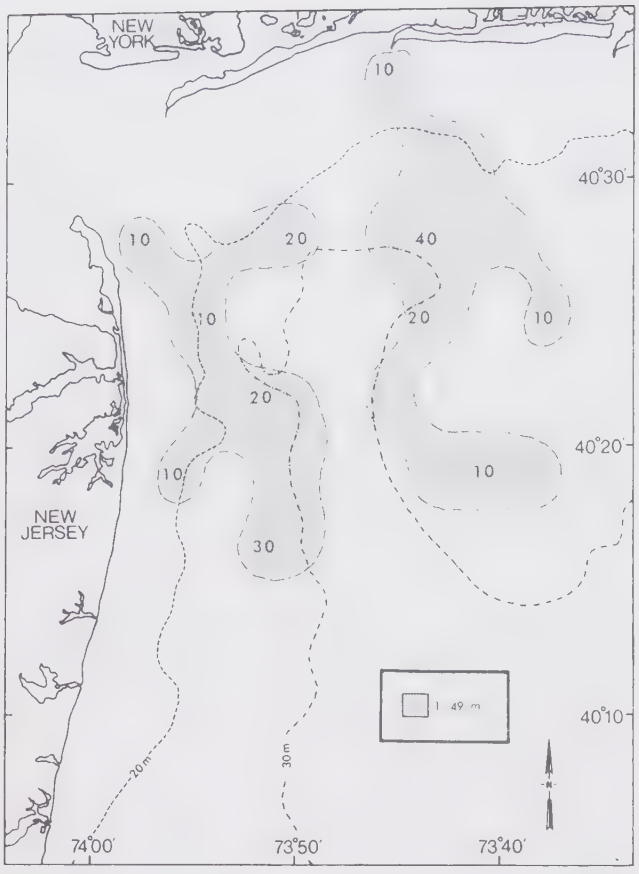

Figure 67.—Distribution and abundance of *Cancer irroratus* in the New York Bight apex.

FEEDING ECOLOGY: This species is known to be a scavenger and carnivore. MacKenzie (1977) reported that it preys upon small clams, while Scarratt and Lowe (1972) have observed that prey of rock crabs >25 mm in size consisted principally of polychaetes, mussels, starfish, and sea urchins.

Rock crab juveniles and adults are preyed upon by several species of fish including cod, *Gadus morhua*; little skates, *Raja erinacea*; red hake, *Urophycis chuss*; striped bass, *Morone saxatilis*; tautog, *Tautoga onitis*; and haddock, *Melanogrammus aeglefinus* (Field 1907; Bigelow and Schroeder 1953; Wigley 1956; Wigley and Theroux 1965; Reilly 1975; Reilly and Saila 1978).

Ennis (1973) reported that in Bonavista Bay, Newfoundland, *C. irroratus* and other decapods make up almost 50% of the gut contents of the lobster *Homarus americanus*.

REPRODUCTION AND GROWTH: In the Northumberland Strait, Gulf of St. Lawrence, Scarratt and Lowe (1972) found the smallest size at maturity was 60 mm for females and 69 mm for males, with breeding occurring in late summer and fall. Larvae are present in surface waters from June to September. In the Gulf of Maine, Krouse (1976) observed that most females attained sexual maturity between 70 and 80 mm carapace width, with a few at <70 mm. Spawning is believed to occur in late fall and early winter and hatching occurs in spring. In southern New England waters, Reilly and Saila (1978) reported that females in the 21–88 mm carapace width range could produce between 4,430 and 330,400 eggs/individual. The presence of ovigerous females <50 mm in size indicated early sexual maturity. Spawning occurred in the spring with major hatching in May. July was the principal period for larval settlement. In Narragansett Bay, Sastry and McCarthy (1973) found ovigerous females with eggs nearing hatching from late April to early June. Hillman (1964) first found *C. irroratus* larvae in Narragansett Bay in late May, while Frolander (1955) found larvae from April to late October in the same waters. Coastal New Jersey plankton surveys by Sage and Herman (1972) revealed *C. irroratus* larvae in late spring samples. In a Chesapeake Bay study, Sandifer (1975) observed that ovigerous females are infrequent in the bay and most larvae appear to hatch offshore. Although larvae are tolerant of moderate estuarine salinities, zoeae probably are retained within the Bay only by chance. Bay or nearshore populations are apparently restocked by migration or transport by currents of late larval stages and juveniles from the inner shelf area. The optimum growth rate of *C. irroratus* larvae occurs at 15°C and 30‰ (Sastry and McCarthy 1973).

Uneven sex ratios for this species are not unusual. Large male: female ratios have been observed in Maine (Dean 1972),[16] the Northumberland Strait (Scarratt and Lowe 1972), and in Virginia, where there is an absence of females in winter populations (Shotten and Van Engel 1971),[17] possibly the result of population movements restricted to one sex (Jones 1973).

Cancer irroratus lives for 7 to 8 yr (Reilly and Saila 1978). In the Middle Atlantic Bight, active molting takes place in April and June (Haefner 1976) and growth ceases in winter.

ADDITIONAL INFORMATION: Vargo and Sastry (1977) conducted an experiment to determine the tolerance limits to acute temperature and combinations of temperature and low dissolved oxygen stresses for five zoeal stages and the megalops of *C. irroratus*. Results showed that the acute temperature limits for a 120-min exposure were all approximately 29.0°C, with little interstage variation, while those for 240 min ranged from 27.3° to 28.5°C. Most interstage variation was shown when temperature and low dissolved oxygen were combined, with low oxygen tolerance decreasing as temperature increased. The megalops is relatively insensitive to changes in oxygen concentration with temperature. It was concluded that larval stages have the capacity to tolerate a wider range of these variables than they experience in the natural environment.

In another study, Bigford (1977) cultured larvae of *C. irroratus* and exposed them to 0.0, 0.1, and 1.0 ppm concentrations of a water-accommodated fraction of No. 2 fuel oil under static conditions. Behavioral changes were monitored in terms of water column reponses to various conditions of light, pressure, and gravity. The most important effects of these sublethal exposures were the reversals of normal larval gravity responses in the water column. Results were that the normally geonegative, early stage larvae moved lower in the water column and the normally benthic megalops stage rose in the water column. This depression of typical megalopal benthic behavior in exposed larvae could alter recruitment to adult populations. As noted previously, Sandifer (1975) stated that *C. irroratus* apparently do not return to their adult habitats during planktonic stages. Instead, late larval stages and juvenile crabs join adult populations via extensive migrations. Therefore, alteration of late larval stage benthic behavior patterns could keep most larvae out of bottom shoreward currents that aid in recruitment movements. It was also determined that the 1.0 ppm concentration of this fuel oil is very near the lethal dose for these larvae.

[16]Dean, D. (editor). 1972. The University of Maine's Sea Grant Program for 1 May 1971 to 30 April 1972. Univ. Maine, Orono, 25 p.

[17]Shotten, L., and W. Van Engel. 1971. Distribution, abundance and ecology of the rock crab (*Cancer irroratus*) in Virginia coastal waters of the Chesapeake Bight of the Virginia Sea. Va. Inst. Mar. Sci. Rep. 40, 3 p.

Phylum Echinodermata

Class Echinoidea

***Echinarachnius parma* (Lamarck, 1816)**

DESCRIPTION: This flat, circular echinoderm is the common sand dollar. It is usually purple-brown in color when alive and uninjured, but changes to dark green when exposed to air, injured, or recently dead. Size up to 83 mm in diameter (Lohavanijaya 1964).

DISTRIBUTION: This species is discontinuously circumboreal, being found both in the North Pacific and North Atlantic, but not in Arctic regions. In the western North Atlantic, the known range extends from Cape Hatteras to Labrador and Greenland (Mortensen 1948; Durham 1955); Lohavanijaya (1964) reported specimens observed from the Bahamas and Cuba, but Virginia is the limit of the U.S. coastal population.

HABITAT: Coe (1972) reported that in the northern part of its range, *Echinarachnius parma* is found near the low water mark, but further south it occurs only in deeper water, to 2,500 m. Lohavanijaya (1964) found them abundant in the surf zone in Maine. In the New York Bight apex, they were located in depths ranging from about 10 to 30 m (Fig. 68), however, they are known to occur in New York-New Jersey outer continental shelf samples in depths exceeding 75 m (Pearce, Caracciolo, Halsey, and Rogers 1977a). Stanley and James (1971) reported that the distribution of this species off Nova Scotia can be closely related to mean grain size of sediments. They were most abundant in fine (2–3ϕ) to medium (1–2ϕ) clean sands, not being found in very fine sand or in well-sorted sand. In the New York Bight apex, this species was also collected almost exclusively in fine or medium sand with an organic content of $<3\%$ (Fig. 68; Table 1). *Echinarachnius parma* is sensitive to anoxic conditions, and while they may be found in areas of organically enriched sediment sublayers, Parker (1927) reported that they will not burrow there. During the anoxic problem in the New York Bight in 1976, the *E. parma* population in a large area, over 1,000 km^2, was killed (Steimle and Radosh 1979). Redford (1978) reported that *E. parma* may also be sensitive to sewer outfalls because of a significant decrease in occurrence and abundance in an area off southern Long Island, 5 yr after the installation of a sewer outfall.

FEEDING ECOLOGY: *E. parma* has been reported to be both a deposit and suspension feeder. Stanley and James (1971), Coe (1972), and Timko (1976) regarded this species to be a microphagous deposit feeder, subsisting on microscopic organisms, particularly diatoms and other algal material. Phelan (1977) reported little or no sand in the intestinal tract, indicating *E. parma* is a selective feeder. In the Pacific, Sokolova and Kuznetsov (1960) and Zenkevitch (1963) considered the species to be a suspension feeder, based on their observations of high concentrations in some areas, such that individuals touch or overlap.

Feeding is accomplished by the use of some of the weak tube feet, cilia, and mucus strands (Parker and Van Alstyne 1932; Hyman 1955; Sokolova and Kuznetsov 1960; Phelan 1977), which collect and move food particles along furrows to the ventral mouth. Feeding may occur while the species is on the surface or burrowing in the sediment.

Ruddell (1977) found that approximately 8% of the sand dollars he examined in the New York Bight had commensal ciliates

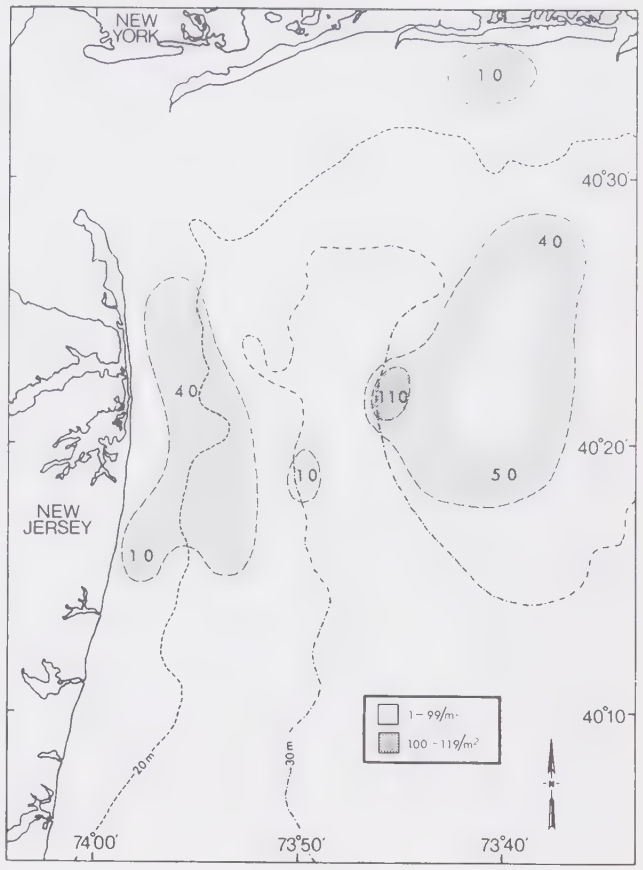

Figure 68.—Distribution and abundance of *Echinarachnius parma* in the New York Bight apex.

attached to their tests. Similar ciliates were noted on asteroid starfish.

Coe (1972) reported that "in many localities, the species [*E. parma*] is so abundant as to form an important part of the food supply of certain fishes, particularly the flounder, codfish and tautog." In the northwest Atlantic, Maurer and Bowman (1975)[18] found *E. parma* to comprise 94% by weight of the diet of Conger eel, *Conger oceanicus*, 54–71% of the diet of ocean pout, *Macrozoarces americanus*, and 40–67% of the diet of American plaice, *Hippoglossoides platessoides*.

REPRODUCTION AND GROWTH: Cocanour and Allen (1967) reported that this species spawns during the fall (September-December) in Maine, and Ruddell (1977) reported similar findings in the southern New York Bight. Fewkes (1886) reported the appearance of larvae in September in Rhode Island. Maurer et al. (1976) reported finding juveniles (<5 mm) in early November off Delaware. Graef (1977),[19] after examining the size distribution of *E. parma* collected in New York Bight apex samples, suggested that new recruits (>10 mm) are available all year but peak in March. Ruddell (1977) found ripe females present from spring

[18]Maurer, R., Jr., and R. Bowman. 1975. Food habits of marine fishes of the northwest Atlantic. Northeast Fisheries Center Data Report, Woods Hole, Mass., Lab. Ref. 75-3, 90 p.

[19]Graef, J. 1977. A preliminary investigation of the growth rate and natural history of *Echinarachnius parma* (Lamarck) in the New York Bight apex area. Unpubl. manuscr., 25 p. Northeast Fisheries Center Sandy Hook Laboratory, National Marine Fisheries Service, NOAA, Highlands, NJ 07732.

through fall off New Jersey and Costello et al. (1957) reported spawning in the Woods Hole region to occur between March and August.

Ruddell (1977) reported that sexual maturity is attained when individuals reach a size of 27 mm or larger off Delaware, while Cocanour (1969) reported gonad development at a size of about 40 mm in Maine, when the organisms are about 3 yr old.

Juveniles are reported to grow very slowly during the winter (Gordon 1929). Males and females occur in equal abundance without any size differential. Cocanour (1969) reported that maximum growth in Maine occurs during seasons of warmest water temperature, March through September. She also reports that during the winter there is some "negative" growth or shrinkage. The sand dollar may have alternating years of growth or gamete production, which may not occur simultaneously. Average growth rates were estimated at 2.0–6.4 mm/yr over a 24–30 mo period for mid-sized (30–50 mm) specimens. Durham (1955) estimated the age of a 48 mm Woods Hole specimen to be 7 yr, based on growth ring analysis, indicating a growth rate of almost 7 mm/yr. Graef (footnote 19) reported the maximum size *E. parma* found in New York Bight apex samples was 53 mm, at an age of about 6 yr, and Brykov (1975) reported a maximum age of 21 yr in specimens from the Sea of Japan, both estimates again based on growth ring analysis. This implies a growth of <9 mm/yr in the Bight apex. Younger individuals have a faster growth rate than mature individuals and Ebert (1975) suggested that, for many echinoids, growth is variable from season to season and from year to year.

Swan (1966) reported that *E. parma* is fully capable of regenerating nipped edges.

ADDITIONAL INFORMATION: *E. parma* has been reported to occur in numbers up to 180 individuals/m^2 off Nova Scotia (Stanley and James 1971) and over 200/m^2 in the North Pacific (Zenkevitch 1963). In the New York Bight apex, the maximum concentration found was 110/m^2. Steimle and Stone (1973) collected 195 individuals (>10 mm in diameter) in a 0.0625 m^2 sample (or 3,120/m^2) northeast of the apex boundaries. Graef (footnote 19) noted a tendency of size classes to be segregated in the New York Bight apex. Cocanour (1969) noted the tendency of larvae to aggregate together, but she believed that as animals get larger they become more evenly distributed. However, the collections reported upon above would indicate nonrandom aggregations of adults as well as larvae.

An interesting phenomenon which has been discovered is the presence of dark, heavy mineral grains in the intestinal diverticula of juvenile *E. parma*. Gregory (1905) noticed them first and Graef (footnote 19) also noticed them in New York Bight specimens. One hypothesis for this phenomenon is that these heavy grains are used as weights by juveniles to increase stability on the bottom.

Stanley and James (1971) reported that this species moves randomly over the sediment. In areas of high concentration, these movements are responsible for modifying ripple microridge and swale topography. Parker (1927) studied the locomotion of *E. parma* and found that it was a combination of rotation and progression. The maximum rate of progress was 18 mm/min, with the average about 14 mm/min. They can completely bury themselves in about 10 min and are capable of righting themselves if turned upside down. Hyman (1955) reported that locomotion is chiefly or wholly accomplished by the motion of the spines, however, Parker and Van Alstyne (1932) indicated that the peripheral tube feet are also of assistance in locomotion.

DISCUSSION

Faunal Composition of the Apex

Among the species in the apex reviewed in this atlas, the Polychaeta were dominant, representing over 64% of total individuals, followed by the Bivalvia representing over 30%. This relative abundance also holds true for the overall species composition (Fig. 69; Table 1). These species contain elements of major benthic faunal types, correlated with sediment composition, reported or defined elsewhere in the Middle Atlantic Bight. The selected species exhibited four general patterns of abundance concentrations: 1) Species which appeared most often in the fine sediments of the Christiaensen Basin and upper Hudson Shelf Valley; 2) species which appeared to be ubiquitous or generally widespread; 3) species which usually inhabited the shallower sandy areas near the New Jersey-Long Island shore and Cholera Bank; and 4) a few species whose distributions were irregular.

The first abundance distribution pattern included 20 species which were generally most abundant in the relatively deep, cool, silty-fine sand habitat offered by the Christiaensen Basin and upper Hudson Shelf Valley (Table 2). This habitat included the sewage sludge dump site and, peripherally, the dredge spoil dump site. Most of the species in this silty-sand apex assemblage show affinities to the following generalized faunal types defined by Pratt (1973): an estuarine silt-clay fauna (*Nephtys incisa*, *Nucula proxima*, *Ninoe nigripes*, *Lumbrineris tenuis*, *Pitar morrhuanus*, and *Cerastoderma pinnulatum*); a marine silty-sand fauna (*Pherusa affinis*, *Ceriantheopsis americanus*, and *Arctica islandica*); and an estuarine silty-sand fauna (*Leptocheirus pinguis* and *Prionospio steenstrupi*). The *Nephtys incisa-Nucula proxima* fauna is common in Long Island (Sanders 1956) and other southern New England sounds (Sanders 1968; Pratt 1973; Steimle et al. 1976[20]), Chesapeake and Delaware Bays (Kinner and Maurer 1978). The marine silty-sand fauna is a major faunal type on the mid-continental shelf and in southern New England sounds. The estuarine silty-sand fauna is usually dominated by *Ampelisca* spp. and also occurs in New England sounds and in mid-Atlantic estuaries. Thus, the spe-

[20]Steimle, F., C. Byrne, R. Reid, and T. Azarovitz. 1976. Hydrology, sediments, macrofauna, and demersal finfish of an alternate disposal site (East Hole in Block Island Sound) for the Thames River (Conn.) dredging project. Final Report to the U.S. Navy, New London, Conn. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Middle Atlantic Coast. Fish. Cent. Informal Rep. 110, 63 p.

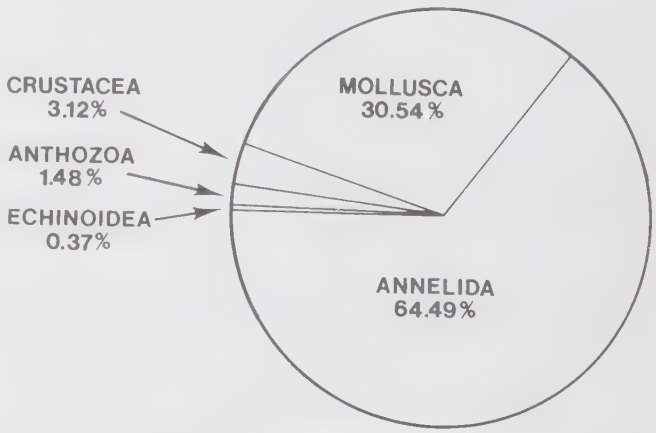

Figure 69.—Percentages of New York Bight apex benthic invertebrates in each phylum represented.

Table 2.—Species whose abundance distributions indicate an association with fine silty sands with relatively high organic contents, as found in the Christiaensen Basin and upper Hudson Shelf Valley (Fig. 1). Feeding types and stress area tolerances (X = high tolerance, L = low tolerance) are also indicated.

Species	Dredge spoil	Sewage sludge	Feeding type[1]
Edwardsia spp.	L		S-SD
Cerianthеopsis americanus	X	L	S-SD
Phoronis architecta	L	L	S
Nucula proxima	L		SD
Arctica islandica	L		S
Cerastoderma pinnulatum			S
Pitar morrhuanus	X		S
Eteone longa	L		C
Nephtys incisa	L	L	O-SD
Capitella capitata	L	X	D
Mediomastus ambiesta	X	L	D
Prionospio steenstrupi	X		SD
Paraonis gracilis			D
Lumbrineris tenuis	X	L	C
Ninoe nigripes	L	L	C
Drilonereis longa	L		C
Cossura longocirrata			D
Asabellides oculata	L	X	SD
Pherusa affinis	L	L	SD
Leptocheirus pinguis			S

[1]Feeding type codes: S = suspension feeder, SD = surface deposit feeder, D = subsurface deposit feeder, C = carnivore, O = omnivore, and SV = scavenger.

cies we have collected in the Christiaensen Basin and upper Hudson Shelf Valley appear to be part of a continuum, transitional, or a mixture of three previously defined major community types which prefer high levels of silt and intrude into the inshore, predominantly sand, habitat within the confines of the upper Hudson Shelf Valley, and in Raritan Bay (McGrath 1974). The two capitellids, *Capitella capitata* and *Mediomastus ambiseta*, in this group are recognized opportunists. Feeding types of the 20 species within this group are diverse.

The second pattern included 17 species whose abundance and wide distribution in the apex could not be strongly correlated with a particular major habitat (Table 3). It included two species, *Spio filicornis* and *Polydora ligni*, that fit this category only during the summer (Fig. 38 (top), 40 (top)).

Most of the species in this group (*Sthenelais limicola*, *Nephtys bucera*, *Aricidea catherinae*, *Cancer irroratus*, *Lumbrineris fragilis*, *Spiophanes bombyx*, *Tellina agilis*) have been found to be members of a medium sand fauna which predominates in inshore areas (Pratt 1973; Steimle and Stone 1973; Maurer et al. 1976; Maurer, Leathem, Kinner, and Tinsman 1979). Two species, *Harmothoe extenuata* and *Edotea triloba*, are members of Pratt's silty sand assemblage, and *Tharyx acutus* and *Polydora ligni* were included as members of the estuarine *Ampelisca* spp. fauna. It should be noted that the collections of *Cancer irroratus* were dominated by juveniles. Examination of adults alone may indicate a far different abundance distribution pattern. This group of species also included a diversity of feeding types, with surface deposit feeders predominating.

The third pattern included those species whose abundance distribution indicated a strong association with the cleaner sandy sediments found inshore, off both New Jersey and Long Island, as well as the Cholera Bank on the eastern edge of the apex. Nineteen species, with a wide variety of feeding types, were included in this group (Table 4). *Spio filicornis* had a more limited distribution in the winter, which included it in this group as well as in the previous group.

Some of the species we have included in this group have been associated with sandy habitats elsewhere. Steimle and Stone (1973) included *Unciola irrorata*, *Protohaustorius deichmannae*, *Rhepoxynius epistomus*, *Echinarachnius parma*, and *Spisula solidissima* as dominants in the medium sand assemblage identified along southwestern Long Island. Most of these same species and *Magelona riojai*, *Goniadella gracilis*, *Nephtys picta*, and *Crangon septemspinosa* are included as dominants in Pratt's (1973) Middle Atlantic Bight sand assemblage. Maurer et al. (1976) found *N. picta* and *Ensis directus* to dominate medium to coarse clean sand stations on the inner continental shelf off the Delmarva Peninsula. *Nephtys picta*, *Spiophanes bombyx*, and *M. riojai* dominated sandy shoals in the Delaware Bay study of Kinner and Maurer (1978).

It is interesting to note that *Neomysis americana*, as it was collected in this survey, showed a preference for the mouth of the Hudson-Raritan Estuary. This could be an artifact of sampling, as the grab used is not particularly effective at collecting these mobile, semipelagic crustaceans.

The three final species, *Ensis directus*, *Nassarius trivittatus*, and *Polydora ligni* (during winter), exhibited an abundance distribution which lacked a definite pattern so as to be placed in any of the above three groups (Figs. 15, 23, 40 (bottom)). Their occurrence,

Table 3.—Species whose abundance distributions indicate a lack of strong association with any particular habitat. Feeding types and tolerances of stress areas (X = high tolerance, L = low tolerance) are indicated.

Species	Dredge spoil	Sewage sludge	Feeding type[1]
Tellina agilis	X	X	SD
Polygordius triestinus	L	L	D
Phyllodoce arenae	L	L	C
Harmothoe extenuata	L		C
Sthenelais limicola	L	L	C
Glycera dibranchiata	X	X	C-D
Nephtys bucera	L	L	O-SD
Spio filicornis (summer)	X	L	SD
Polydora ligni (summer)	X	X	SD
Spiophanes bombyx	X	X	SD
Aricidea catherinae	L	L	D
Lumbrineris fragilis	L	L	C
Tharyx acutus	X	X	SD
Tharyx annulosus	X	L	SD
Ampharete arctica	L		SD
Edotea triloba	X	X	SV-SD
Cancer irroratus	L	L	SV-C

[1]For feeding type codes see Table 2.

Table 4.—Species whose abundance distributions indicate an association with clean sand habitats. Feeding types are included.

Species	Feeding type[1]
Astarte castanea	S
Spisula solidissima	S
Goniadella gracilis	C
Nephtys picta	O-SD
Nephtys (Aglaophamus) circinata	O-SD
Travisia carnea	D
Spio filicornis (winter)	SD
Lumbrinerides acuta	C
Magelona riojai	D-SD
Caulleriella killariensis	SD
Ampelisca verrilli	S
Unciola irrorata	O-SV-SD
Pseudunciola obliquua	SD
Protohaustorius deichmannae	S
Protohaustorius wigleyi	S
Rhepoxynius epistomus	O
Neomysis americana	S-SD
Crangon septemspinosa	O-SV
Echinarachnius parma	S-SD

[1]Feeding type codes are listed in Table 2.

however, may indicate a preference for a transitional habitat between the fine silty sand and cleaner sand in the New York Bight apex. *Ensis directus* is a suspension feeder, *N. trivittatus* is considered a scavenger, and *P. ligni* is a surface deposit feeder.

Pratt (1973) included *E. directus* in his Middle Atlantic Bight sand community, and Franz found both *E. directus* and *N. trivittatus* to be characteristic of the medium sand assemblage in Long Island Sound. However, *N. trivittatus* has also been recorded from muddy sediments in Delaware Bay (Kinner et al. 1974). The summer distribution of *P. ligni* places it in the ubiquitous species category, however, its winter distribution is more limited.

The diversity and mixing of previously defined faunal groups in the deeper areas of the apex, especially the silty sand area, is, more than anything else, probably a reflection of the heterogeneity of the sediments there, disregarding local impacts of dumping. The sediments in the apex have been examined in great detail by Freeland et al. (1976), showing a complex distribution of surficial sediment types, including relic and anthropogenic deposits, as well as normal current and wave related distributions.

Anthropogenic Influences

The seabed of the New York Bight apex is influenced primarily by continental shelf water of high salinity (>32‰) and small temperature fluctuations. Inshore areas are less stable and fall under the influence of ocean waves and estuarine discharges, primarily from the Hudson-Raritan Estuary. The estuarine discharges contain relatively high levels of suspended sediment, organic material, and nutrient and toxic pollutant loadings, all of which contribute to altering the quality of the benthic environment, both inshore and in the deeper offshore depositional basins of the apex. Waste dumping also directly and indirectly impinges upon the benthos. The net result of decades of using the Hudson-Raritan Estuary and the apex as a repository for a variety of human wastes is that the apex benthic environment, particularly the sediments in and around the dredge spoil and sewage sludge dump sites, now contains a variety of contaminants occurring at levels that are stressful, lethal, or undesirable to many marine organisms. For example, high levels of five heavy metals have been measured, in our survey, in both the dredging spoils and sewage sludge dump sites (Figs. 7–11). They are, in general, correlated with sediments of highest organic content (Fig. 6). Metal concentrations in these areas are, in some cases, almost 50 times higher than those at apex stations away from the dump sites and background levels in uncontaminated sands and silt (Table 5).

Koons and Thomas (1979) also reported that total C_{15+} hydrocarbons are highest (3,600–6,500 ppm) in New York Bight areas where harbor dredge spoil and sewage sludge disposal occurs. Levels at the mouth of the Hudson-Raritan Estuary are reported as low as 6–22 ppm, with concentrations of 82 and 86 ppm reported at two locations approximately 80 km out on the mid-continental shelf.

Table 5.—Concentrations of metals in sediment unaffected by waste dumping (ppm in dry sediments) (Carmody et al. 1973).

	Cr	Cu	Pb	Ni	Zn
Sandy sediment of New York Bight	6	3	12	3	18
Silty sediment of Hudson Submarine (Shelf) Valley	6	5	14	8	20

Elevated levels of heavy metals and hydrocarbons are well known as being toxic to marine life. In high concentrations, they are lethal, but even in sublethal concentrations they can cause pathological conditions, physiological disturbances, and deviations from normal behavior. Larval stages are especially sensitive to heavy metal toxicity and usually show increased abnormalities and slow growth rates when exposed to such toxins (Sprague 1964; Saunders and Sprague 1967; Shuster and Pringle 1968[21]; Portmann 1970; Stirling 1970[22]; Calabrese 1972; Connor 1972; Calabrese et al. 1973, 1977; Vernberg et al. 1973; Reish et al. 1974).

The Christiaensen Basin and upper Hudson Shelf Valley benthic environments are also subject to frequent seasonal dissolved oxygen reductions to levels (<2 ml/1iter) critical to many species of marine organisms common in the New York Bight (Segar and Berberian 1976; Steimle 1976; Thomas et al. 1976). The dissolved oxygen reduction during the summer months is probably the result of the higher oxygen demand of organic rich sediments and overlying water in the central apex depression, coupled with the strong seasonal thermocline which prevents reoxygenation of bottom waters.

Impacts to the benthic community are strongly indicated in our data. Some abnormalities in faunal composition appear to be directly related to the dumping of dredge spoils and sewage sludge. Most of the species found in the upper Hudson Shelf Valley and Christiaensen Basin exhibited some avoidance of one or both dump sites (Tables 2–4) with a few exceptions: *Capitella capitata* was collected almost exclusively at the sewage sludge dump site, and *Asabellides oculata* occurred in greatest concentrations there; *Prionospio steenstrupi* and *Lumbrineris tenuis* showed high abundances at the dredge spoil dump site (Figs. 2, 35, 39, 46, 55).

The very low H' diversity values (Fig. 3), observed at stations within and just outside both dump sites, indicate that the overall benthic macroinvertebrate community structure in these areas has also been altered. Low H' values are often associated with highly stressed environments, where a few opportunistic or tolerant species become abundant, in part because of reduced competition. This results in a simple community, usually consisting of only a few species (Sanders 1968). In this study, the sewage sludge dump site was dominated by *Capitella capitata*, a highly opportunisitic species, and our data show the abundance distributions of only eight species to indicate tolerance of sewage sludge, all are deposit feeders. Thirteen species were observed to be tolerant of dredging spoils. Of these, 11 are deposit feeders, 1 is a suspension feeder, and 1 is a carnivore (Tables 2, 3). This predominance of deposit feeders in and around the dump sites indicates that there may also be a change in trophic composition of communities in these areas. An examination of the feeding types of all species in Groups 1 and 2, i.e., those which are ubiquitous or most often associated with fine sand-silt sediments with generally high organic content, shows a more equitable distribution of feeding types (Tables 2, 3).

Amphipod crustaceans, found to be important elements in most faunal groups described in the Middle Atlantic Bight, are virtually absent from coarse to medium silts and medium to high organic content sediments in apex collections, an observation previously reported by Pearce (1972). The marine silty sand group defined by Pratt (1973), which intrudes up the Hudson Shelf Valley to the

[21]Shuster, C., and B. Pringle. 1968. Effects of trace metals on estuarine molluscs. *In* Proceedings of the 1st Mid-Atlantic Industrial Water Conference. Univ. Delaware, CE-5, p. 285–304.

[22]Stirling, E. 1970. Some observations on the response of the benthic bivalve *Tellina tenuis* to pollutants. Proc. Int. Counc. Explor. Sea, C.M. 1970/E:15, Fish. Improvement Comm., 6 p.

apex, contains several species of *Ampelisca* which are considered important elements of this faunal group, and in the silty sand areas of southern New England sounds they are numerical dominants. Ampeliscids also dominated many estuarine silty sand faunas, e.g., in southern New England (Sanders 1958), in Great Bay, N.J. (Durand and Nadeau 1972), in Chesapeake Bay (Feeley 1967), and in the Delaware Bay area (Watling and Maurer 1972). In our apex study, however, only one species of *Ampelisca* (*A. verrilli*) was collected, in moderate numbers, in low organic, fine to medium sandy sediments. The one species of amphipod, *Leptocheirus pinguis*, which was moderately abundant in high organic, silty sediments, was collected only at the southernmost stations of the upper Hudson Shelf Valley (Fig. 63), while Steimle and Stone (1973) collected it in the northern Christiaensen Basin in 1967.

The paucity of amphipods in the New York Bight apex and Raritan Bay (McGrath 1974) would appear to be very good evidence that man's use of the area has generally degraded the environment so that it is unsuitable for most amphipods. The dump sites are a part of this degradation, but a small part compared with the effects of pollution effluents in and emanating from the Hudson-Raritan Estuary. Amphipods, like other crustaceans, are known to be generally intolerant of pollutants (Blumer et al. 1970; Sanders et al. 1972), but they are important food items for most demersal finfish and their absence or reduction in numbers may alter normal food webs of several valuable resource species, reducing the potential harvest from the apex. Boesch (1982) has reviewed benthic-finfish trophic couplings in the apex, and also supports the hypothesis that resource potential is impaired.

The apex, in the past, has been a very productive area for fisheries, in part because of its uncontaminated shellfish and because it provided a hospitable environment for many species of demersal fish and crustaceans. If dumping in the area is reduced or terminated in the future, it will be important to monitor the recovery of the apex ecosystem.

The amount of time required for the fauna at these dump sites to recover is unknown at this time. Dean and Haskin (1964) found that the benthic community, particularly the small amphipod crustaceans, showed marked recovery after pollution abatement at the mouth of the Raritan River. Dredge spoil recolonization has also been shown to be relatively rapid in Long Island and Rhode Island Sounds (Pratt 1973; Reid and Frame 1977[23]). However, little work has been done on sewage sludge dump site recovery. Bioturbation may keep recycling some pollutants for a time before they are finally diluted to nonstressful levels or buried at a depth where they are no longer active.

In conclusion, our studies show that a heterogeneous benthic fauna exists in the New York Bight apex, which appears to be adversely altered, particularly in the vicinity of two dump sites, but perhaps throughout a major portion of the apex.

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[23]Reid, R., and A. Frame. 1977. Sediments and benthic macrofauna of disposal area, Section F. *In* Physical, chemical and biological effects of dredging in the Thames River (CT) and spoil disposal at the New London (CT) dumping ground, p. 1–44. Final report to U.S. Navy and Interagency Scientific Advisory Subcommittee on Ocean Dredging and Spoiling, NOAA, NMFS, Northeast Fisheries Center, Sandy Hook Laboratory, Highlands, N.J.

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